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EDITORIAL

The state of nature-reporting, Scotland 2024

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A significant proportion of this issue of *The Glasgow Naturalist* is occupied by a Supplement of 11 articles based on the proceedings of the GNHS Scottish Herpetological Conference, which was held in the Advanced Science Centre of the University of Glasgow on 3rd June 2023 as part of the Glasgow Science Festival. A theme running through most of these articles is anthropogenic influences on our herpetofauna. These include positive influences, such as the many man-made bodies of water that expand available habitat for amphibians (Downie *et al.*, 2024); negative influences, such as the threatened weakening of wildlife protection laws (Tse-Leon, 2024); and "the jury is out" influences, such as the consequences of beaver (*Castor fiber*) re-introductions (Wilson *et al.*, 2024). Whilst all ten of Scotland's native amphibians and reptiles are allocated to the "Least Concern" category in the IUCN Red List, five species are reported as declining across their global range (IUCN, 2024) and one of these – the natterjack toad (*Epidalea calamita*) – is endangered in Scotland (McInerny & Minting, 2016). There is therefore no cause for complacency.

Members will be aware that the previous issue of the journal also featured a major Supplement based on conference proceedings and, like the present issue, consisted of around 100 pages, which is the target number. Apart from one rejected paper, all non-conference articles received by the submission deadlines for both issues were ultimately accepted for publication. This indicates that the submission rate for normal articles was low over the past two years, and in fact there has been a general decline in the submission rate since the 2019 issue, which contained 25 normal articles. However, as 14 to 20 articles were submitted for each of the 2014-2018 issues, there seems to be no long-term trend.

The 14 non-conference articles in this issue demonstrate the usual taxonomic diversity, ranging from Cyanobacteria (blue-green "algae") through turtles (Testudines) to natural history organisations (Kelvin Biodiversity Network and Glasgow Museums Biological Records Centre). Also as usual, the dominant group represented is the Insecta, the subject of six articles, which is not surprising when *ca.* 14,000 of Scotland's total of *ca.* 24,000 invertebrate species are insects (Buglife, 2024).

It can be taken for granted that scientific articles, such as those published in *The Glasgow Naturalist*, aim to achieve the highest levels of factual accuracy. Unfortunately, this appears not to be the case for media reporting of science in general and natural history in particular. Two recent press articles typify this point. On 4th March of this year, *The Herald* included a full-page article on swifts (*Apus apus*) illustrated with a large photograph of a swallow (*Hirundo rustica*) clearly displaying its unmistakable red forehead and throat (Dick, 2024). Later in the same month, a *Herald* article on Arctic charr (*Salvelinus alpinus*) was illustrated with a mislabelled photograph of a brown trout (*Salmo trutta*). This article also stated that Arctic charr "is currently under threat from invasive species", specifying these as being (amongst others) "non-native vendance" [*sic*] (*Coregonus albula*), "non-native pike" (*Esox lucius*) and "non-native perch" (*Perca fluviatilis*) (Nutt, 2024). This is misleading because vendace are widely accepted as native to the south of Scotland, i.e. they arrived there post-glaciation by natural dispersal, and pike and perch are probably also native to the south of Scotland, though this is more controversial. The current presence of these fish species further north in Loch Earn and other lochs inhabited by Arctic charr is a result of human intervention, and in that sense alone they are not native to these particular lochs (Colin Adams, pers. comm.). The article also failed to note the important points that vendace is Scotland's and the U.K.'s rarest freshwater fish, and that it was deliberately introduced into Loch Earn in an attempt to form a conservation refuge population following the disappearance of the fish from its two historical Scottish locations in Dumfriesshire (Lyle *et al.*, 2019) – hardly the credentials of an invasive species.

Another casualty of media mangling over the past year was the latest *State of Nature Scotland* report (Walton *et al.*, 2023). Newspaper articles have repeatedly misrepresented the findings of this report. For example, according to Micklewright (2023) "One in nine species threatened with extinction is just one of its shocking conclusions." The unqualified mantra that one in nine, or 11%, of Scottish species is threatened with extinction has been widely disseminated by the press and various

organisations (Williams, 2023; Dick, 2024; Ross, 2024; Loch Lomond and the Trossachs National Park, 2024; RSPB, 2024). None of these sources explains that this does not refer to 11% of all Scottish species, which would be truly shocking, but to 11% of the 7,508 Scottish species assessed using IUCN Red List criteria. As Scotland has an estimated total of 60,000 species (excluding microbes) (NatureScot, 2021), the report actually implies that 1.4% of all species are at risk of extinction, not the more sensational 11%.

There is, of course, much good, accurate reporting of natural history subjects – no need to declare a nature-reporting emergency yet – and it is perhaps understandable that journalists (and picture editors) with no background in science and with copy deadlines to meet sometimes get things wrong. They do, however, have as much a duty of care to the truth as naturalists and other scientists, and especially so when they are reaching a much wider readership.

ACKNOWLEDGEMENTS

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Kelvin Biodiversity Network: a decade of co-operation and citizen science

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ABSTRACT

Formed in the autumn of 2013, Kelvin Biodiversity Network (KBN) focuses on the biodiversity of, and issues facing the lower River Kelvin, which is essentially the stretch of the waterway flowing through the city of Glasgow, Scotland. The network reaches about 30 organisations, mainly non-governmental organisations (NGOs). We describe KBN's activities involving member groups working together, specifically on a conference, regular bio-recording and an annual exhibition, and discuss its achievements (especially in citizen science), limitations and possible futures.

INTRODUCTION

In the autumn of 2013, the Council of Glasgow Natural History Society (GNHS) discussed a suggestion from Friends of the River Kelvin (FORK) that there was a need for more biodiversity recording along the urban stretches of the river and its surroundings, partly to provide evidence of biodiversity value in the light of possible development proposals. Council agreed that Roger Downie, Richard Weddle and Lyn Dunachie (all Council members but also with roles in other relevant groups and organisations) should convene a meeting of stakeholders to explore this idea. An initial meeting of five people (the three listed above plus Lucy Reynolds of FORK and Gemma Jennings of the Clyde River Foundation (CRF)) took place in December 2013. This paper describes and assesses the activities of the Kelvin Biodiversity Network (KBN) that arose from that meeting, and which has operated since.

THE RIVER

The Kelvin, a river of about 35 km, has its source east of Kilsyth near the village of Banton, North Lanarkshire. It flows southwest, joined by the Glazert Water and Luggie Water near Kirkintilloch, then by the Allander Water at Bardowie, East Dunbartonshire, then south through the west end of Glasgow to join the River Clyde at Partick. The Kelvin has seen many centuries of modification by people, such as canalisation, straightening and the creation of weirs for industrial uses (Hume, 2018), including paper-making and flour-milling. Although the last mills on the river closed by the 1970s, they have left a series of weirs and mill lades, and related transportation systems have left railway bridges and tunnels, now all out of use and/or derelict, except for the most spectacular of them, the Kelvin Aqueduct, carrying the Forth and Clyde canal high above the river at Maryhill. Industrial effluent along with waste-water led to the river being highly polluted, and essentially dead in terms of the wildlife it could support: one of us (JRD) can remember the stench and cloudy appearance of the water in the 1960s. However, the closure of the mills and improved sewage treatment measures led to gradual improvement. The Clyde River Purification Board began monitoring the Kelvin for invertebrate and aquatic plant diversity as measures of pollution levels in 1979 and this has been continued to the present by its successor organisation, the Scottish Environmental Protection Agency (SEPA). Early signs of improvement in the lower Kelvin were the appearance of stonefly (Plecoptera) larvae in 1999, followed by pollution-sensitive cased caddisflies (Trichoptera) in 2005. Overall scores have improved fairly steadily over the monitoring period (Arnold *et al.*, 2018). These improvements have paid off in terms of other species returning to the river, such as salmon (*Salmo* spp.), otters (*Lutra lutra*) and kingfishers (*Alcedo atthis*), but pollution events still occur (Scott, 2018). The full length of the Kelvin and its banks in Glasgow is now designated as a Site of Importance for Nature Conservation (SINC), and this includes Yorkhill Park, Kelvingrove Park, Glasgow Botanic Gardens and Dawsholm Park, which has the additional status of Local Nature Reserve. To the north of the city is an additional SINC at Millichen Flood, East Dunbartonshire, on the Kelvin floodplain, an important site for wading birds. The stretches of the river through East Dunbartonshire and North Lanarkshire also include important wildlife sites such as Balmore Haughs and Buchley Sandpit. Another improvement has been the creation of the Kelvin Walkway, a path which allows walkers and cyclists to travel the 14 km from the river's confluence with the Clyde to Milngavie, where serious hikers can start the West Highland Way (which ends in Fort William, Lochaber).

THE MEETINGS

During the ten full years in which KBN has been active, we have had on average seven meetings a year (i.e. slightly more than bi-monthly). For the first six years, these were held in the Graham Kerr Building, University of Glasgow, but this pattern ground to a halt after February 2020 when the COVID-19 pandemic restrictions came into force. Meetings resumed that August, but this time online using the *Teams* or *Zoom* platforms, and we have retained that format ever since, because it allows the busy people who contribute to KBN to participate without spending time travelling to

a venue. One outcome of the initial meeting was the assembly of a list of other organisations to be invited to participate in the network. In practice, groups have had three kinds of involvement: a) core members, who have attended and contributed to most meetings: these are GNHS, FORK, the Royal Society for the Protection of Birds (RSPB - Glasgow office), The Conservation Volunteers (TCV), Yorkhill Greenspaces and Friends of Glasgow Botanic Gardens (FGBG); average attendance over the 12 meetings to June 2023 is eight; b) occasional attenders: over the years, these include CRF, the Children's Wood, Glasgow City Council ranger and biodiversity services, and East Dunbartonshire's biodiversity officer; c) mailing list members, who tend not to attend meetings, but do receive minutes of meetings and other information from the network, and who may contribute to activities. All types of member are listed as e-mail addresses on the KBN contact list, currently 35 individuals (Table 1). For data protection reasons, the mailing list is held solely by the GNHS membership secretary, who distributes all mailings.

Each meeting includes reports and updates from the organisation representatives attending, consideration of any current issues such as planning applications, and discussion of upcoming activities (see below). To give a flavour of the topics discussed at our meetings, we give a short list taken from KBN meeting minutes.

- After a few initial meetings, the CRF representative drew our attention to a 2011 report written by Nick Underdown, a British Trust for Conservation Volunteers (now TCV) communities trainee: the report had recommended the establishment of some kind of network to address the issues facing the Kelvin and its tributaries. Members read the report, which contained ideas similar to those we were developing, but Nick had hoped to involve the whole river and its catchment, a much bigger task than we could deal with.
- Sand martins (*Riparia riparia*) have been observed nesting near the Kelvin's confluence with the Clyde. The network discussed how to enhance this nesting site and the promotion of another potential site at Garscube estate. An outcome was the siting of an artificial sand martin wall at Garscube, funded by GNHS's Blodwen Lloyd Binns bequest.

a) Frequent and occasional attenders at meetings
*Glasgow Natural History Society
*Friends of the River Kelvin
*Royal Society for the Protection of Birds
Glasgow Botanic Gardens
*Friends of GBG
Glasgow City Council Biodiversity Officers
Glasgow City Council Countryside Rangers
*The Conservation Volunteers
Friends of Yorkhill Park
North Kelvin Meadow and Childrens' Wood
East Dunbartonshire Biodiversity Officer
Clyde River Foundation
b) Others occasionally involved or otherwise interested at some time
University of Glasgow GALLANT Project
University of Glasgow Campus Biodiversity Working Group
*Glasgow Museums Biological Records Centre
Friends of Glasgow West
Friends of Kelvingrove Park
*Friends of Glasgow's Local Nature Reserves
Glasgow City Council Sustainable Glasgow Partnership
Woodlands Community Garden
c) Other organisations contributing to Kelvin at the Kibble
Tom Donald Photography
Scottish Environmental Protection Agency
Upstream Battle (Keep Scotland Beautiful)
Scottish Water
Froglife
Clyde Amphibian and Reptile Group
Photoscot
Scottish Wildlife Trust
Glasgow National Park City
*Friends of the Earth Glasgow

Table 1. Organisations currently taking part in the Kelvin Biodiversity Network. Asterisks indicate those contributing to most *Kelvin at the Kibble* exhibitions.

- TCV has developed a "Dead Good Dead-wood" project aimed at discouraging the clearance of rotting timber so that the fungi and invertebrate species utilising dead wood can be encouraged This project was much discussed by the network and has led to management changes along the forested banks of the river, particularly along stretches managed by Glasgow Botanic Gardens.
- The network had discussions on the need for a nature trail in leaflet form covering the urban Kelvin either in one leaflet, or in several sections. An earlier trail had covered Kelvingrove Park, and the Glasgow Treelovers' Society had produced a guide to the trees in the park. The discussions contributed to the production of junior leaflets for the Botanic Gardens, and a more advanced one for Kelvingrove.
- RSPB Glasgow's Giving Nature a Home team have worked with schools and communities for over 10 years, aiming to connect people with nature. In the west end of the city, this has included a schools programme at Kelvingrove Art Gallery and Museum, and developing Hillhead High School as a Species Ambassador school. The team's work is regularly highlighted at KBN meetings, including bioblitzes, creation of a demonstration wildlife garden in the Botanic Gardens, developing wildflower meadows and hedgerows, and enhancing house sparrow (*Passer domesticus*) habitat in collaboration with citizen scientists and the University of Glasgow.
- In recent years, the Botanic Gardens have become the venue for events such as the summer drama performances of "Bard in the Botanics" and the winter light and sound show "Glasglow". The network has contributed to discussions of the environmental impacts of these events, especially any impact on biodiversity, and the need for proper assessments.
- Scottish Water has carried out major works along the urban Kelvin, aiming to improve waste water treatment. The works required considerable tree felling and temporary path relocation. The network has discussed the arrangements for re-instatement but particularly the need for planting of appropriate species of trees.
- A major planning application for the Kelvin valley on the outskirts of the city came to the network's attention and, after discussion, we helped spread information on what was planned and its likely impact on biodiversity.
- The diversity of invertebrate species living in the river provides a measure of the water's ecological health. The Scottish Environmental Protection Agency (SEPA) does some sampling along the Kelvin, but the network feels there is scope for a citizen science contribution. This clearly needs training, since the species can be hard to identify, and there are safety issues in sampling from the river.

ACTIVITIES

The first meeting included a brainstorm of the possible scope of the network and its potential actions. It was agreed initially that the scope would be the River Kelvin and its immediate surroundings as it passes through the city of Glasgow, from the city boundary to the river's confluence with the Clyde at Partick. As noted below, engagement with the Kelvin beyond the city has been limited so far. The network was intended not to be a competitor to existing organisations but to organise activities that would benefit from groups working together and help to publicise the activities of member groups. Potential activities identified were: bioblitzes aimed at improving biological records; educational activities focused on the river; and contributions to Glasgow Science Festival (GSF), focusing on the science of the river.

Conference: The River Kelvin - its History and Natural History

The idea for a conference on the River Kelvin came up at a KBN meeting in October 2014. The city aimed to burnish its environmental image by designating 2015 as the Green Year, with each month having its own environmental theme, and GSF had decided to follow this theme. KBN offered to contribute a conference to the Festival and this was soon accepted. We brainstormed possible topics and agreed that it would be valuable to include an account of the historical uses of the river, as well as its natural history, since the two themes are likely to be interlinked. Some invited speakers felt unable to give an account focused on the Kelvin, but there was no difficulty in filling a day's programme with seven substantial talks, introduced by the chairs of the network's two founders, GNHS and FORK, and followed by an entertaining picture quiz and facilitated discussions giving the audience a chance to air views on topics such as invasive plants and the potential for power generation along the river. On the day, 6th June 2015, about 80 people attended. The printed programme included full abstracts of all the topics covered and a list of forthcoming events related to the Kelvin, including talks and excursions. Jon Barnes led a walk along the Kelvin on the day after the conference. It had always been intended that the conference proceedings should be published in *The Glasgow Naturalist.* In the event, this took longer than expected, papers not appearing online until December 2017 and in print the following March (Downie, 2018). Of the seven conference talks, we received publishable versions of only four, plus the text and illustrations from a poster as a short note. This was disappointing, but the published talks are substantial, especially John Hume's account of the industrial uses of the river, accompanied by historical illustrations, and Keith Watson's update of the river's flora.

Bio-recording

An initial aim of KBN was to accumulate more

knowledge of the biodiversity along the river and its immediate surroundings. The network has contributed to this in various ways, especially as a promoter of bioblitzes, a citizen science bio-recording activity, such as those organised by the RSPB in the Botanic Gardens in 2017 (Fig. 1) and Kelvingrove Park for City Nature Challenge (the first of these occurred in 2019 as a Nature Discovery Day, associated with the visit to Kelvingrove Museum and Art Gallery of the Natural History Museum's Dippy the Dinosaur) and the 30th anniversary of the Glasgow Garden Festival (2018). In July 2016, the network discussed the idea of revisiting the biodiversity recording project carried out by GNHS in the Glasgow Botanic Gardens two decades before (published as Hancock, 1998, 1999). The project would coincide with the celebration of the Gardens' bicentenary (1817-2017) and, as before, would focus on recording species living in a wild state in the Gardens. The plan was to publish papers based on bio-records accumulated over the previous 20 years, to broaden the scope of the animal and plant groups covered, but also to carry out one or more new bioblitzes. A bioblitz in September 2017 added 71 new species records for the Gardens (Forster, 2018). In the event, preparation of the papers resulting from the project took longer than anticipated, resulting in a very substantial output, 18 papers published over three issues of *The Glasgow Naturalist* (volume 27, parts 1, 3 and 4).

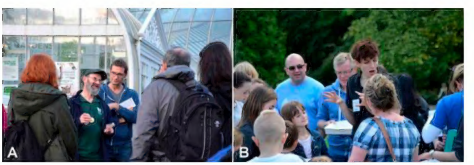

Fig. 1. The Glasgow WildFest bioblitz, Botanic Gardens, September 2017. (A) The species identification laboratory. (B) Explaining worm charming. (Photos: Gregory Vaux, RSPB)

Apart from the bioblitz events, the extra effort included regular night insect-trapping sessions, with identification of as many as possible, principally moths and caddis-flies. A visit by a mollusc expert added substantially to the species found in the glass-houses, and a survey aimed at spiders also added more insects, plus, surprisingly, freshwater turtles (Cathrine & Monir, 2022). The list of papers does not include an update of the flowering plant list, but many plant records were added by Botanical Society of the British Isles recorders. Roy Watling visited the gardens with a display of fungi and led a short foray, later contributing a substantial paper (Watling, 2019) on the non-lichenised fungi of the Gardens over 200 years (including at the previous Sandyford site). Watson (2022) covered the bryophytes and Wilkie (2022) the lichens. Overall, many species new to Glasgow and even some new to Scotland were recorded during this project, with a chart of the discoveries published as Table 3 in Weddle & Downie (2021). The ever-increasing species list can be found at www.gnhs.org.uk/biodiversity/GBG_splist.pdf. An additional recording effort has been aimed at the small parks at Yorkhill, close to the river's confluence with the Clyde: Yorkhill Greenspaces seem to add new species records each month, totalling 1,355 by September 2023. In 2023, a new project began to accumulate data on the distribution of animals and plants along the urban stretch of the Kelvin. This is part of the GALLANT project, a collaboration between the University of Glasgow, Glasgow City Council, local voluntary organisations and individual volunteers. The project's website can be accessed at https://www.inaturalist.org/projects/river-kelvin-wildlife-glasgow.

Kelvin at the Kibble

For many years, FORK had held an annual summer gala based around their headquarters, Halfpenny Bridge House. This had included stalls publicising the work of groups other than FORK itself. The gala was a huge effort for a small organisation, and very dependent on the weather. The network came up with a different, simpler plan: an exhibition put on by contributing groups celebrating the river and its biodiversity, with the obvious location being the foyer and main corridor of the Botanic Gardens' Kibble Palace. This idea was first discussed in July 2015: the then manager of the Gardens, Ewen Donaldson, was quick to agree that we could use the Kibble for a fortnight free of charge, and the first exhibition happened in May-June 2016. Nine groups produced exhibits; the event had an official opening; on most days, exhibits were unstaffed (so had to be self-explanatory), but the middle Saturday was advertised as a "family day" to include events such as a story-teller and guided walks, and with most exhibits staffed. *Kelvin at the Kibble*, as the exhibition has been named, has continued since 2016 (Fig. 2). The 2017 event was restricted to the south wing of the Kibble, because much space was needed for the Gardens' bicentenary celebration. The first three exhibitions simply celebrated the river and provided information on stakeholder groups, but since 2019, each exhibition has had a theme: pollution in 2019, highlighting a core activity of FORK, which carries out monthly clean-ups along the river. In 2020, we planned to shift the exhibition to September and to focus on climate change, as a link to the UN's COP26 climate change conference in Glasgow. However, the COVID-19 pandemic delayed both COP26 and our exhibition until autumn 2021. In May 2022, our theme was the biodiversity crisis, associated with the other big UN environment conference, COP15's review, in China, of the progress of the Convention on Biological Diversity. In 2023, we returned to pollution, as news reports flooded in of sewage releases into England's rivers (and the resultant effects on fish and other animal groups), by the privatised water companies. Over the seven years of *Kelvin at the Kibble*, the number of contributing groups has been 22 with some present every year (Table 1).

DISCUSSION

KBN has now existed for over a decade, but is essentially simply a mailing list. We have no constitution, no formal structure and no source of funding. The network persists because the people on the mailing list appreciate its existence. The lack of funding and a

AN EXHIBITION ORGANISED BY THE KELVIN BIODIVERSITY NETWORK
Riverside CLEAN UP
EXHIBITORS
KELVIN at the KIBBLE
Find out how you can get involved with local groups in Glasgow to help protect the River Kelvin
Where The Kibble Palace Glasshouse, Botanic Gardens, Glasgow
When 16 - 29 May 2023
Time 10am - 4pm
A
B

Fig. 2. *Kelvin at the Kibble*. (A) Poster advertising the 2023 *Kelvin at the Kibble* exhibition (poster designed by Lyn Dunachie). (B) Visitors studying the Friends of the River Kelvin stall at the 2023 exhibition. (Photo: Lyn Dunachie)

formal structure means that the network can have no campaigning role. Rather, it can exchange information and promote the activities of contributing organisations. The network has been able to organise some limited activities: the *Kelvin at the Kibble* exhibition relies on the willingness of contributing organisations to exhibit their material, and the Botanic Gardens to provide space. The Kelvin conference was funded by the Blodwen Lloyd Binns Bequest, GNHS's trust fund. In our view, the network will persist as long as contributing organisations want it to, and there is no need for any formal structure.

Some of the activities involving KBN's members can be termed "citizen science", especially the bio-recording work. The idea of citizen science, as an activity where ordinary citizens contribute to the accumulation of scientific knowledge, originates in the 1990s (Irwin, 1995). Much of the knowledge gained concerns biodiversity, but citizen science is multi-disciplinary and also international (Wikipedia, 2023). There has been much debate on how to ensure that knowledge gathered by citizen scientists is reliable, with training and new technology both involved.

We contend that the continuation of the network over ten years, and its stimulation of the various activities described here demonstrate its usefulness. Some permanent outcomes are the conference proceedings and the new species records added with the encouragement of the network. We have been less involved in commenting on planning applications and their impacts on biodiversity than might have been expected, but, as noted earlier, the network's role on such issues is restricted to information dissemination.

So far, KBN has been involved mostly with the urban Kelvin. We have made contact with East Dunbartonshire Council's biodiversity staff, but they have had limited input so far, and we have had no contact with any NGOs that operate along the river outside the city. Given that environmental interests are often localised, this lack of reach may be no bad thing, but we intend to keep trying for wider involvement. An exciting recent development is a plan to restore the meanders in the East Dunbartonshire stretch of the river, allowing the formation of wetlands with good visitor access.

The future of KBN will be determined by the network's active members. We hope to continue with our annual exhibitions; we are sure that there are more species to record, perhaps especially in groups where identification is more challenging, and this may require more engagement with training; and, as noted earlier, the issues concerning the river beyond Glasgow's boundaries are relatively unexplored.

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Only one subspecies of the scotch argus *Erebia aethiops aethiops* (Esper) exists in Britain

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ABSTRACT

The scotch argus (*Erebia aethiops*) is a locally abundant butterfly typically on the wing during August in large areas of Scotland and at two sites in northern England. It is currently accepted by many that in Scotland two subspecies – *Erebia aethiops caledonia* (Vérity) and *Erebia aethiops aethiops* (Esper) - exist in different areas and that these differ morphologically. *E. a. caledonia* is slightly smaller and has three ocelli (eyespots) on the upper fore and hind wing, whereas *E. a. aethiops* has four or more ocelli. We have surveyed four areas presumed to hold either one or the other subspecies but found that both forms exist in all areas and that *E. a. caledonia* was always the more common form. While there may be other areas that are the sole domain of one or the other form, our findings do not support the contention that two subspecies exist. These findings and the fact that there is continuous variation between the two variant extremes represented by *E. a. caledonia* and *E. a. aethiops* leads us to suggest that the subspecies *E. a. caledonia* is invalid and that this form ought to be considered only as a variant of the nominate species *Erebia aethiops aethiops* (Esper).

INTRODUCTION

The scotch argus is a butterfly of coarse damp grasslands with flushes, mires and wet woodland (Kirkland, 1995, 2004, 2012). It is the last non-migratory butterfly to peak in the late summer in Scotland and in areas with colonies is usually the most abundant species at that time. The species was first described in Scotland by Dr John Walker as "*Papillo amaryllis*" in a notebook now in the possession of the University of Edinburgh, having been discovered as early as 1760 in Bute (Stephens, 1827; Thomson, 1980). The butterfly was then renamed *Erebia blandina* (Stephens, 1856), this generic name perhaps being derived from the ancient Greek *Erebus,* meaning "darkness", in reference to the dark colour of this group. It was finally named *Erebia aethiops,* the specific name derived from the Greek for "red/brown". Subsequently it was claimed that a subspecies *caledonia* existed in Scotland (Vérity, 1911) but this was complicated by the fact that this author was comparing the *caledonia* subspecies found in Galashiels in the Scottish borders to continental "alpine" members of the species, not to other populations within the U.K. We know now that the British population differs substantially from continental European populations in habitat use in that the continental populations are dependent on forests (Slamova *et al.*, 2012; Wendt *et al.*, 2021), whereas many U.K. colonies do not seem to directly depend on forests (Kirkland, 1995). The status as a subspecies claimed by Vérity is also undermined by his own observation that there were transitions between *caledonia* and "the Alpine type", which is assumed to be equivalent to the nominate species *E. aethiops aethiops*. Also, the description given by Vérity of the subspecies *caledonia* was very brief indeed.

Other authors have given fuller descriptions of *E. a. caledonia* and differences between this and *E. a. aethiops* have been suggested. Riley (2007) and Easterbrook (2010) list four attributes. Subspecies *caledonia* is generally smaller, has more elongated and pointed forewings, the orange band is constricted centrally and only rarely contains more than three eyespots, and finally it has a less contrasting hindwing underside pattern. Newland *et al.* (2020) agree that *caledonia* is smaller and that the orange band has a constriction but point out that *E. a. aethiops* sometimes also has this. Thomson (1980) did not mention forewing shape but claimed that the orange band is narrower and nearly always constricted and rarely contains more than three eyespots. Eeles (2019) mentions the smaller size and "less prominent markings". It is notable that in the description of the nominate species Esper (1777) gave an illustration of the three-eye spotted form.

The existence of the two subspecies has become accepted by some, as has the distribution of the two subspecies within the U.K. (Thomson, 1980; Riley, 2007; Newland, 2012a; Newland *et al.*, 2020; *UK Butterflies* at https://www.ukbutterflies.co.uk). However, some other authors are less certain and for example Kirkland (2012, 2022) does not mention subspecies in otherwise full accounts, while Eeles (2019) points out that the "relative distributions of the two subspecies are not clear cut" and Easterbrook (2010) claims that it "is regarded as a subspecies by some lepidopterists". Those who do accept the validity of

these subspecies propose that *E. a. aethiops* exists in the east of Scotland and in surviving colonies in northern England, whereas *E. a. caledonia* is found in western Scotland and the Scottish borders (Fig. 1; Thomson, 1980). There is currently no indication of differences in behaviour between the two supposed subspecies except possible differences in foodplant choice (Newland, 2012a), but this is mostly due to the availability of grass species present (Kirkland, 1995, 2012, 2013). More generally, within Britain, there is no discernible differences in ecology or behaviour within the British populations (Kirkland, 2004).

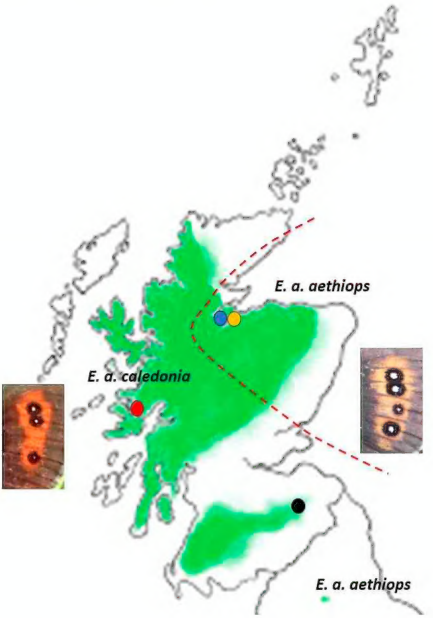

Fig. 1. The green areas show the known distribution of the scotch argus (*Erebia aethiops*) in Scotland and England (https://nbnatlas.org/; Thomson, 1980). The red dotted line shows the approximate separation of the two currently recognised subspecies: the three-spotted *E. a. caledonia* in western and southern Scotland, and *E. a. aethiops* in the eastern Scotland (Thomson, 1980). The northern English colonies are also proposed to be *E. a. aethiops.* The positions of the four study sites monitored during this work are shown by coloured circles (see Table 1). Red: Rhemore; blue: Belladrum; yellow: Milton of Leys; black: Melrose.

METHODS

Surveys were made of four areas in Scotland to determine the frequency of four-or-more (hereafter "≥four")-spotted versus three-spotted forms and other variable morphological features. These surveys were carried out mainly in August of the 2023 season, but data were also collected at the Rhemore near Lochaline, Lochaber site in August 2015 and in August 2022. Adults are generally to be found in the last week of July and throughout August (Kinnear, 2000), but some populations fly earlier (Hume, 2002). All four sites (Fig. 1) featured a similar mixture of damp, non-grazed or lightly grazed grasslands, proximal to mature trees. Wing measurements were made on limited numbers of live butterflies (Fig. 2) with as little handling as possible. We briefly detained "cold" specimens, found resting in tall grass, and measured the maximum wing length by extending the wings against the ruler. It was possible to find specimens resting deep in long grass during periods of dull weather and these could be handled gently for measuring. Adults also instinctively drop into deep grass when disturbed as a defence mechanism (Wilkie, 2019). However, the number of measured individuals (ten) was too low to justify the use of statistical tests, or to draw strong conclusions.

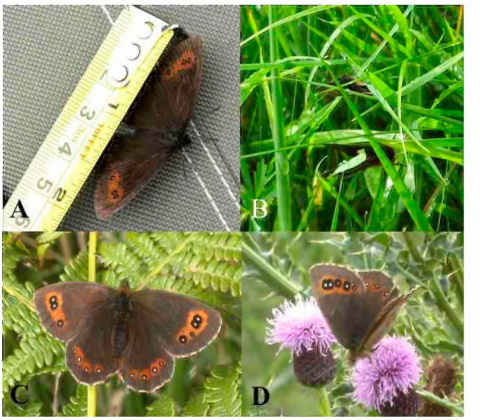

Fig. 2. (A) A "cold" male scotch argus (*Erebia aethiops*) with a wing span of 51 mm (Rhemore). (B) A pair of scotch argus hiding/resting in deep grass during a rain shower. (C) A female scotch argus with a fourth ocellus on one wing only (Rhemore). (D) A female scotch argus with five ocelli (Melrose).

RESULTS

No area was found to contain exclusively one variety of the species, all containing a mixture of both (Table 1). The *E. a. caledonia* phenotype (the three-spotted form) was dominant in all four areas investigated. Several individuals were found within areas supposedly of ssp. *caledonia* that were as large as or larger than the *E. aethiops aethiops* (Fig. 2A). Three-spotted forms also had three spots on the upper hindwing also and four spotted forms also had four spots on their upper hindwing.

DISCUSSION

In total we found that 23.5% of the sampled scotch argus butterflies had ≥four-spotted forewings and 76.5% were three-spotted forms. This agrees with the one-in-four estimate for the overall Scottish population (Thomson, 1980). However, the figure for southwest Scotland was only 2% (Thomson, 1980) while our Melrose site (within the southwest Scotland area) had 20%. It is possible that this is a very local difference, but it is also possible that our figure is higher as we recorded even a black dot at this position on the forewing as an eyespot and we do not know what criterion was used by

Site	Number of individuals with three ocelli	Number of individuals with four or more ocelli
Malthouse Burn beside golf course (Melrose, Scottish Borders) 55.583505°N 2.728043°W 199 m above sea level	62 (79.5%)	16 (20.5%%)
Rhemore (near Lochaline, Lochaber) 56.591512°N 5.959346°W 54 m above sea level	36 (75%)	12 (25%)
Belladrum (near Beauly, Inverness-shire) 57.444226°N 4.465141°W 44 m above sea level	14 (74%)	5 (26%)
Milton of Leys (south-east Inverness) 57.450128°N 4.171381°W 167 m above sea level	8 (66.6%)	4 (33%)

Table 1. Details of Scottish survey sites described in this paper. Sites are colour-coded as shown in Fig. 1.

Fig. 3. (A) A male scotch argus with three ocelli on the forewing, corresponding to the *E. a. caledonia* phenotype. (B) A female scotch argus with four ocelli on the forewing, corresponding to the *E. a. aethiops* phenotype.

Thomson. This fourth spot (between veins 3 and 4) (Thomson, 1980) is very variable, from a single black punctum to a full ocellus with a white centre. We have found that some individual images have a fourth small ocellus on one wing but not on the other (Fig. 2C). Furthermore, some specimens have an additional fifth spot (Fig. 2D) (Mercer *et al.*, 2009), and some even have a sixth (Newland *et al.*, 2020).

Like many satyrid butterflies, variations in the patterns and colour of the wings of scotch argus have been reported. An unusual form in which the orange band on the forewing was greatly expanded and in which there were no bands on the underside of the hindwings was recorded in northern England (Russwurm, 1971). A form known as *croesus* in which the eyespots are enlarged is reported (Thomas & Lewington, 2016). Newland (2012b) described variants of spot patterns in the upper hind wings in a population near Lochaline. This was only 13.5 miles from the Rhemore site and yet we found no such variants in this area in searches conducted in 2015, 2022 and 2023. Within the populations studied here, it is the number and pattern of eyespots on the upper forewing surface that are the most obvious variant feature. Three-spotted forms are known as *E. aethiops* subsp. *caledonia* (Fig. 3A) and four-spotted forms have become known as *E. aethiops* subsp. *aethiops* (Fig. 3B). Although Newland (2012b) did not mention numbers from his study at Lochaline, he did publish four photographs of *E. a. caledonia* phenotypes and none of *E. a. aethiops* in his paper, in agreement with our findings.

The definition of what constitutes a subspecies has been controversial (Mallet, 2007), but a generally accepted version has been offered. According to Patten & Unitt (2002) a subspecies "is a collection of populations occupying a distinct breeding range and diagnosably distinct from other such populations". We argue here that the current available information concerning *E. a. caledonia* is not compatible with this definition by multiple criteria. None of the reported differences are unique to the alleged populations, which is incompatible with the "diagnosably distinct" requirement for the status of a subspecies. Also, as the areas occupied by *E. a. aethiops* and *E. a. caledonia* share a border, this is

incompatible with the requirement for a "distinct breeding range".

However, there are two distinct subspecies of the related meadow brown (*Maniola jurtina*) found in east and west Europe, separated by intermediate forms (Thomson, 1969, 2011). Genetic studies have been conducted on populations of scotch argus from northern England and the Highlands and islands of Scotland (Gunson, 2019; Gunson *et al.*, 2023) and, although this study did not directly address the question of the validity of the subspecies *caledonia,* the results showed a general cline between the Highlands/islands and northern English populations. There was no evidence for overall differences between, for example, populations in Skye and Mull on the west coast (previously presumed to be *caledonia* territory) (Fig. 1), and the Insh marshes, Highland, Tomnavoulin, Moray, and Craigower, near Pitlochry, Perth & Kinross, towards the centre and east (presumed to be *aethiops* territory). This genetic study utilised a polymerase chain reaction (PCR) based amplified fragment length polymorphism (AFLP) technique that amplifies subsections of the genome, thereby creating a genome-wide fingerprint (Paun & Schönswetter, 2012). If *E. a. caledonia* were to be a genuine subspecies this method would be predicted to demonstrate differences between *E. a. caledonia* and *E. a. aethiops.* For example, AFLP was used to demonstrate that the butterfly species considered to be the Demeter longwing (*Heliconius demeter*) was actually two subspecies despite the fact that no difference could be detected in the adults' morphology (Rosser *et al.*, 2019).

It is still possible that areas exist in which exclusively three-spotted or ≥four-spotted forms exist. These may be individual colonies or groups of colonies, but even if they were found to exist, we suggest that they would not justify a subspecies status. Certainly, more accurate wingspan measurements should be made to test the hypothesis that the *caledonia* variety are significantly smaller than the *aethiops* variety, as previously stated, or whether there are significant differences in overall wingspan between the 3-spotted and ≥4-spotted forms. It would be helpful to measure male and female of both types also. Our initial crude measurements indicate that no such differences exist, but we would need many more, and more accurate, measurements from populations across Scotland and England to be conclusive on this point.

We conclude that the subspecies *Erebia aethiops* ssp. *caledonia* does not exist, the U.K. population instead containing a variety of forms, some of which may show local differences in the frequency of various morphological features. Genetic studies (Gunson *et al.*, 2023) indicate that whereas a general cline of variation is evident from north to south, there is no evidence to support the existence of a *bona fide* subspecies *caledonia* within the Scottish population. We suggest that the three-spotted form is only a variation and should be described as *Erebia aethiops* var. *caledonia* rather than *Erebia aethiops* ssp. *caledonia.*

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Glasgow Museums Biological Records Centre: achievements over the past 25 years and future prospects

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ABSTRACT

The development of Glasgow Museums Biological Records Centre from its inception in 1997 to the present is described, along with geographical and taxonomic coverage of the records. The principal sources of records are listed, and the contribution of online recording systems in recent years is highlighted. Data accuracy, gaps in taxonomic coverage, and new taxa possibly resulting from climate change are discussed. Finally, the possible future of the Centre in the context of the Scottish Better Biodiversity Data project is outlined.

INTRODUCTION

There has long been a close association between Glasgow Natural History Society (GNHS) and Glasgow Life Museums. The Society was instrumental in donating specimens and setting up the early natural history displays in Kelvingrove House, the predecessor of Kelvingrove Art Gallery and Museum (Sutcliffe, 2016). In an earlier paper (Weddle, 2001), we described the history of biological recording in the Clyde area, up to the establishment for the first time of an electronic biological records database for Glasgow Museums Biological Records Centre (GMBRC). This database, run using Recorder 3 software on a desktop computer housed in the basement of Kelvingrove Museum, was begun in the summer of 1997 with the help of six temporary assistants. It had reached about 115,000 records by the time the 2001 paper was written and has now been in existence for over 25 years (Fig. 1). As the database has recently passed the million-records milestone it seems an appropriate time to review what has been achieved by this GNHS/Glasgow Life Museums collaboration, and to consider what the future might hold for GMBRC.

OVERVIEW OF GMBRC'S RECORDER DATABASE

Data Software

The original Recorder 3 system, developed by Stuart Ball of the Joint Nature Conservation Committee, ran on the Microsoft DOS operating system. This was the system used when the GMBRC started in 1997, but the records were exported from there to the new Microsoft Windows application using a Microsoft (MS) Access database known as Recorder 2000/2002, which was subsequently developed as Recorder 6 on the MS SQL Server platform.

Fig. 1. Richard Weddle at the GMBRC desktop PC after it moved from Kelvingrove Museum to Glasgow Museums Resource Centre, Nitshill, *ca.* 2008. (Photo: R. Sutcliffe)

The core species list is based on the U.K. Species Inventory (UKSI) maintained by the Natural History Museum, London. There is a sophisticated internal cross-referencing system which relates older taxon names and synonyms to "preferred names". It can also report older taxon names as taxon aggregates where there has been historical confusion or where the taxon has been shown to include new species. For instance, records of the harvestman *Dicranopalpus ramosus*, are reported as *ramosus sensu lato,* except where a post-2015 key has been used to identify them and they have been explicitly input as *ramosus sensu stricto*. The rather similar *D. caudatus*, previously thought to be synonymous with *D. ramosus*, was confirmed as present in the U.K. in 2015.

Data Sources

Many of the historical sources of records were described in Weddle (2001). Up to that time GMBRC prioritised data that fell within the 1996 city boundary or close by, mainly because of the launch of the first Glasgow Local Biodiversity Plan (LBP) in that year (Glasgow City Council, 2001), which included extensive lists of species known to exist, or thought to exist, within the City boundary. This "Glasgow Species Audit" has been updated several times since then. An extract, consisting of the species listed in the most recent audit along with the number of records and the earliest and latest years (where known), is available online (GNHS, 2023).

In the subsequent years we gradually added the missing historical records for the rest of the Clyde area and have also included records from outwith that area where they formed part of a significant dataset. This includes museum specimens collected by locally significant naturalists, and in some cases data from their field notebooks. The most significant additions to the sources of data have been continuing efforts by individual naturalists, including downloads from the various online recording systems such as BirdTrack, iRecord and iNaturalist. These recording systems have themselves facilitated a significant increase in recording effort as part of general community science initiatives, such as those described by The Natural History Museum in London (NHM, 2023). At various times we have received data, often in exchange for updates from our records, with national recording schemes such as the Scottish Squirrel Survey and Scottish Badgers.
Further sources will be highlighted below, in the relevant context.

Data Services

Over the years GMBRC has provided: datasets in support of reviews of scarce and threatened species; records for environmental consultants in connection with proposed developments (housing, commercial, wind farms etc.); species lists for designated sites for Biodiversity Officers in the various Local Authorities in the area; species lists for the Biodiversity area of the GNHS website; records or species lists for academic purposes; and species lists for entire Local Authorities (species "audits").

Perhaps most importantly, we have uploaded over 19,000 records directly to the National Biodiversity Network (NBN). Many of these had been prepared as a response to enquiries, such as national reviews of particular taxon groups, though some datasets were submitted to flag up significant range expansions of some of the constituent species in the area. The uploaded datasets are listed in Table 1. Further details on these, together with other information including statistics showing why the data has been accessed, are available at NBN (2023). Many more GMBRC records have been submitted via U.K. recording schemes, such as the National Moth Recording Scheme, the Trichoptera (caddisfly) Scheme, and the British Dragonfly Society.

One of the most important functions of local environmental records centres is data verification: they have a local perspective on both the taxa which occur in the area, and the recorders who send in records. This process includes data reviews, for example a review of the historical amphibian and reptile records for *The Glasgow Naturalist* (McInerny, 2020) looked at many records that had been transcribed from publications by the national Biological Records Centre in the last quarter of the 20th century. The review highlighted a number of unlikely or unverifiable records, which were fed back to the current custodians of the records at the U.K. Centre for Ecology and Hydrology and the GMBRC database was amended appropriately.

CURRENT RECORDS

At the time of writing (8th November 2023) there are 1,038,646 records in GMBRC's database. Whereas the 2001 list included only Glasgow records, the database now covers a much larger area comprising mainly neighbouring local authorities in our "core area" of west central Scotland, although there are also records from further afield. Table 2 indicates the coverage of the "core area" and some peripheral areas, but excludes remoter records. These remote records are typically records supplied by museum collections, and can be from as far away as East Malling in Kent.

For the former county of Renfrewshire, excluding the part within Glasgow, i.e. Renfrewshire, East Renfrewshire and Inverclyde, there are 309,577 records, 29.7% of the overall total. *The Flora of Renfrewshire* records form a significant part of this total as well as contributing to the Glasgow total (Watson, 2014). Many

Class/Order	Superfamily/Family
Diptera	Tephritoidea (picture-winged flies)
	Conopidae (thick-headed flies)
	Hippoboscidae ((louse flies, or keds)
	Nycteribiidae (bat flies)
Coleoptera	Carabidae (ground beetles)
	Chrysomelidae (leaf beetles)
	Coccinellidae (ladybirds)
	Byrrhidae (moss beetles)
	Clambidae (fringe-winged beetles)
	Dascillidae (orchid beetle)
	Phalacridae (shining flower beetles)
	Monotomidae (root beetles)
	Oedemeridae (false blister beetles)
	Silphidae (burying beetles)
Hemiptera (true bugs)	
Orthoptera (grasshoppers, crickets etc.)	
Mammalia (both terrestrial and marine)	
Angiospermae (flowering plants)	Orchidaceae

Table 1. Datasets uploaded by GMBRC to the National Biodiversity Network.

Local Authority	Records	%
City of Glasgow	257,255	24.7
Renfrewshire	182,666	17.5
South Lanarkshire	106,162	10.2
East Dunbartonshire	100,221	9.6
East Renfrewshire	69,290	6.7
Argyll and Bute (only VC99 is a core area)	65,395	6.3
Inverclyde	57,621	5.5
North Lanarkshire	57,393	5.5
South Ayrshire	53,321	5.1
West Dunbartonshire	43,813	4.2
Stirling	43,079	4.1
North Ayrshire	15,176	1.5
East Ayrshire	4,048	0.4

Table 2. Numbers and percentages of records in the GMBRC database by Local Authority (west central Scotland only). Core coverage areas of GMBRC are italicised.

of the North Ayrshire records pertain to the parts of Clyde Muirshiel Regional Park within that local authority. Similarly, many of the East Ayrshire records pertain to the western part of Whitelee Windfarm Country Park. In addition, many of the Ayrshire records pertain to specimens in the Hunterian and Glasgow Life Museums collections, and records gleaned from books and journals.

A table of the number of records within the taxon groupings used by Recorder 6 is given in the Appendix. This table is similar to that given in Weddle (2001), though some of the organismal categories are unavoidably different. However, the categories are a similar mix of phyla, classes and orders because of factors such as the desirability of separating out the various orders of insects. The first column in the table is the number of taxa in the UKSI. These numbers are in some cases rather larger than might be expected because UKSI includes many subspecies, varieties, forms and hybrids, as well as a number of vagrants and other unestablished non-native species. For example, the list gives the number of butterfly species as 129, whereas most sources quote 59 as the number of current native species. However, the larger number seems more appropriate in this context as the records in the database also include the extra subspecies etc., although in both cases nominate trinomials have been excluded (for example *Maniola jurtina jurtina* in the case of meadow brown butterfly).

The other columns in the Appendix are numbers of records for various date ranges: up to 2003, 2003 to 2012, 2013 to 2023, and the total number of records for that organismal group. The numbers show the recording effort across the years, but comparison with the 2001 table, which lists only records in the database up to that year, highlights the fact that many pre-2001 records have been added since then. These include the *Changing Flora of Glasgow*, many of the *Flora of Renfrewshire* records, records gleaned from the pages of journals including *The Glasgow Naturalist* and *Entomologist's Monthly Magazine*, and records, mainly of beetles, extracted from the field diaries of Roy Crowson. The later date-ranges largely indicate the amount of recording effort in the last 20 years, particularly since the recent advent of online recording systems.

A summary of the figures given in the Appendix, using rather coarser organismal categories, is shown in Table 3 and a further summary of the insect groups is shown in Table 4. These illustrate a marked increase in recording of the smaller groups and species that were previously rather under-recorded at the time of the 2001 paper. This is in part due to the efforts of recording groups that have been set up in the last 20 years, including: the Clyde Amphibian and Reptile Group, Clyde and Argyll Fungus Group (though many of their records are not yet included in the GMBRC database), Friends of Hamiltonhill Claypits Local Nature Reserve (LNR), Friends of Glasgow's LNRs, Friends of Havoc Meadow, and Renfrewshire Recording Group. Further significant contributions come from bioblitzes and similar recording events organised by RSPB's *Giving Nature a Home* team, Buglife and The Conservation Volunteers. There are also numerous Facebook groups dedicated to particular taxonomic interests.

The recording effort has been supported over the years by training local naturalists to identify taxa, particularly invertebrates. TCV's "Natural Talent" apprenticeships helped greatly in this respect as the apprentices shared their new-found expertise in short courses linked to field-recording events, as well as their own field-recording. There were similar training courses, of one or two days, held at Glasgow Museums Resource Centre and the Hunterian Museum of the University of Glasgow as well as other venues such as community halls. Here the instructors were curators of those museums or visitors from national schemes such as the Hoverfly Recording Scheme or the Conchological Society of Great Britain and Ireland. Butterfly Conservation staff and volunteers have also contributed training events in the field at various parks and other local conservation sites.

However, there remain some under-recorded groups. The Ichneumonidae is a challenging group but many of the larger species can be identified from detailed photographs by experts who monitor the online

Group	Records added Pre-2003	Records added 2003-2012	Records added 2013-present	All records
Micro-organisms	51	36	253	340
Fungi	969	1,778	6,225	8,972
Lichens	662	197	222	1,081
Lower plants	5,527	507	1,020	7,054
Vascular plants	234,637	29,696	29,788	294,121
Arachnids	908	714	1,098	2,720
Insects	122,676	69,907	149,688	342,271
Other invertebrates	4,189	4,300	3,079	11,568
Lower chordates	-	3	-	3
Fish	303	199	63	565
Amphibians	1,505	2,108	1,698	5,311
Reptiles	849	124	129	1,102
Birds	33,874	30,886	285,796	350,556
Marine mammals	31	28	26	85
Terrestrial mammals	2,332	2,852	7,669	12,853
Grand Total	**408,513**	**143,335**	**486,754**	**1,038,602**

Table 3. The number of records for each organismal group in the GMBRC database.

Order	Records added pre-2003	Records added 2003-2012	Records added 2013-present	All Records
Silverfish (Thysanura)	4	3	3	10
Bristletails (Archaeognatha)	7	-	1	8
Mayflies (Ephemeroptera)	46	199	155	400
Dragonflies (Odonata)	5,891	1,570	932	8,393
Stoneflies (Plecoptera)	129	79	64	272
Grasshoppers etc. (Orthoptera)	194	51	85	330
Web-spinners (Embioptera)	-	-	-	-
Mantises (Mantodea)	-	-	-	-
Earwigs (Dermaptera)	41	33	76	150
Cockroaches (Dictyoptera)	39	1	4	44
Book/bark lice (Psocoptera)	67	10	20	97
Lice (Phthiraptera)	4	-	-	4
True bugs (Hemiptera)	1,474	605	1,556	3,635
Thrips (Thysanoptera)	5	2	3	10
Stick insects (Phasmida)	-	1	-	1
Snakeflies (Raphidioptera)	7	-	-	7
Alderflies (Megaloptera)	21	20	33	74
Lacewings (Neuroptera)	112	42	66	220
Beetles (Coleoptera)	25,003	2,051	4,804	31,858
Stylops (Strepsiptera)	2	-	-	2
Scorpion flies (Mecoptera)	30	33	45	108
Fleas (Siphonaptera)	33	19	1	53
Caddis flies (Trichoptera)	588	326	525	1,439
Butterflies (Lepidoptera)	15,484	26,115	41,450	83,049
Moths (Lepidoptera)	66,074	31,512	86,857	184,443
True flies (Diptera)	6,070	5,321	6,635	18,026
Bees, wasps etc. (Hymenoptera)	1,351	1,914	6,373	9,638
Grand Total	**122,676**	**69,907**	**149,688**	**342,271**

Table 4. The number of insect records for each Order in the GMBRC database.

recording systems. Many of the smaller plant bugs (e.g. Miridae, Nabidae, Cicadellidae, and Lygaeidae) are also relatively easily identified from detailed photographs, though there are currently few recorders who consider these groups. Most of the non-insect invertebrate groups, and all the micro-organisms listed in the Appendix, with the exception of the cyanobacteria ("blue-green algae"), seem to be largely neglected. In other taxonomic areas there are few active recorders, particularly in the younger age-range, of bryophytes and lichens.

Since 2009 GNHS and BRISC (Biological Recording in Scotland) have offered bursaries towards training courses such as those offered by the Field Studies Council. These have been open to all Scottish residents, and there has been a good take-up by those resident in the central belt of Scotland. Such training has been supplemented in recent years by online training courses, many of which were free or very reasonably priced. These were particularly numerous in the "COVID years" (2020-2022), but have continued since, and many were recorded and continue to be available.

The management of biological records has been further facilitated by the online recording systems mentioned above where the recorder can enter a record in the field and the geospatial coordinates are added automatically. In most cases the application can suggest a possible identification, using artificial intelligence (AI) methods, if a photograph has been submitted. There are, however, a number of actual and potential drawbacks with these systems for the inexperienced naturalist: the geospatial coordinates are of course those of the observer, who may be at some distance from the flora or fauna being reported; the suggestions for the identity of the taxon observed may be biased by the material that has been used for training the AI system – for example, iNaturalist often seems to favour North American species – and even when the recorder wishes to enter a species name manually, they can be presented with a confusing list of possibilities; and the databases used for describing the location can be unhelpful as they tend to be based on gazetteers of street names or electoral wards, and overlook LNRs and other sites of conservation interest. Despite these shortcomings, these systems have undeniably helped to increase the recording effort, particularly as they encourage newcomers by having a system of record verification when a suitable photograph has been provided.

Weddle (2001) mentioned a number of issues with identifying the location of observations. The problem with earlier records was typically their rather generalised locations, such as vice-county, town or parish, though the authors of some published lists devised their own system of subdividing the Clyde area, such as the botanical records in Scott Elliot *et al.* (1901), which was also adopted by Lee (1933). With the advent of the Ordnance Survey National Grid in 1947 it became standard practice to use a grid reference to indicate locations. In general, this was helpful, though it also gave rise to the practice of using the size of the grid square as an indication of the accuracy of the grid reference, which can be unhelpful or even misleading in a number of ways, particularly when the need is to link the record to a named site, such as a park or LNR, rather than simply producing a distribution map at vice-county or national level. The approach taken by the NBN Atlas is one defined by the "Darwin core" specification developed for the Atlas of Living Australia: locations, whether national grid references or latitude/longitude coordinates, are defined by a point with an associated "radius of uncertainty". This is a more scientifically rigorous approach, in that any measurement is always associated with an error that can be defined or at least estimated. When a global positioning system (GPS) is used to find the coordinates, the radius of uncertainty is given by the device used, For example a Garmin device shows an uncertainty reading alongside each spatial coordinate value, and systems such as iRecord and iNaturalist also record the uncertainty with the other geospatial information in their data stores.

This historical trend towards ever greater geospatial precision is now also driven by the increasing use of GIS (Geographic Information Systems) to relate species distributions to habitat maps, which in turn reflects the increasing awareness of the interconnectedness of the natural world, often described as the "web of life". The Recorder database system design includes the ability to link taxon records with habitat data and to specify the substrate, whether that be the tree on which a fungus was found, or a plant associated with an insect larva. In those examples the relationship is obvious, but there is undoubtedly a need for the less obvious inter-relationships to be investigated more fully, for example linking the sighting of a pollinating insect with the habitat requirements of the larval form of that insect.

Such topics also stress the inclusion of human life as part of this web. This encompasses on the one hand the part that the human economy plays in disturbing established ecosystems, and on the other the positive effects of the natural world on the health and well-being of individuals. However, those are aspects that are largely outside the realm of a biological records database, except to emphasise that recording environmental factors such as the conductivity, dissolved oxygen and pH of water bodies in connection with surveys of aquatic flora and fauna are as valuable as the taxon records themselves.

Climate change was not mentioned in the Weddle (2001) paper, but since then a number of previously unrecorded species have been found whose occurrence may indicate climatic change. There were a number of well-documented arrivals of butterfly species into the area prior to 2001 (Futter, 2006), and species such as the comma (*Polygonia c-album*), and the speckled wood (*Pararge aegeria*) in more recent years continue this trend (Fig. 2). Some moths, such as the narrow-bordered bee hawkmoth (*Hemaris tityus*) and the narrow-bordered five-spot burnet (*Zygaena lonicerae*), are now common in suitable habitats in and around Glasgow (GMBRC records). The recent sightings of water

Fig. 2. Speckled wood (*Pararge aegeria*), Holmhills Community Woodland LNR, South Lanarkshire, September 2023. (Photo: A. Park)

Fig. 3. Bee orchid (*Ophrys apifera*), Havoc, West Dumbartonshire, 2022. (Photo: S. Futter)

ladybird (*Anisosticta novemdecimpunctata*) in Glasgow and North Lanarkshire can probably be ascribed to climate change, particularly if it is present in water-bodies between here and the south of Dumfries and Galloway where it is long-established (Weddle, 2024a), though the recent proliferation of the harlequin ladybird (*Harmonia axyridis*) may well be part of a natural spread northwards. The recent occurrences of *Chorisops* soldierflies in Scotland (Weddle, 2024b), could also be a result of climate change. However, other factors may be at work: a number of new shield bug species (Pentatomoidea) have recently been recorded in Greater Glasgow, some of which may well have been spread via the horticultural trade rather than due to climate-related factors (RBW, pers. obs.).

It is possible that many plants, usually non-natives, are benefitting from climate change impacts, but systematic long-term evidence is limited. The bee orchid (*Ophrys apifera*) (Fig. 3) is a native orchid which, during the last 20 years, has spread into Scotland, as exemplified by some very recent local finds at Havoc Meadow, Dumbarton and Greenoakhill Forest, Carmyle (K. Watson, pers. comm.). It is thought that this orchid's winter-green rosettes benefit from milder winters (BSBI, 2020). In the fungus kingdom, the arrival in the Greater Glasgow area in recent years of earthstars - firstly the now widespread collared earthstar (*Geastrum triplex*), followed successively by the sessile earthstar (*G. fimbriatum*) (O'Reilly, 2020), and in 2023, the striate earthstar (*G. striatum*) - may be related to the warmer, more humid conditions.

THE FUTURE: GMBRC

At the time of writing, GMBRC is closed. Over the last 25 years demand for GMBRC's data services has grown dramatically and an official evaluation of the Centre's operations and structure is now required. Glasgow Life Museums have invited the Association of Local Environmental Records Centres (known as ALERC) to help produce a thorough business review which engages relevant stakeholders from across the Clyde area. It will take into account work being done elsewhere in the country, including the Scottish Government's Biodiversity Strategy and National Planning Framework 4 and the Better Biodiversity Data project. We anticipate that the review will create a robust development plan for GMBRC's future.

Despite the closure, GMBRC is still accepting new wildlife records and datasets to ensure the database is up-to-date for reopening. As mentioned, the database recently passed 1 million records. The millionth record input into the database was a sighting of a pellucid hoverfly (*Volucella pellucens*) (Fig. 4) in the Botanic Gardens in August 2021, which was not downloaded from iNaturalist until June 2023. The earliest dated record is of few-flowered sedge (*Carex pauciflora*) in the Arran hills on 21st June 1772, and the latest record is of a noctule bat (*Nyctalus noctula*) at Hamiltonhill Claypits LNR on 30th September 2023.

THE FUTURE: SCOTLAND

As GMBRC goes through its own development and review, the biological recording network across Scotland is also embarking on a new project: the Better Biodiversity Data project (BBD).

The BBD project arose from the activities of the Scottish Biodiversity Information Forum (SBIF) which was established in June 2012 as community-led forum bringing together stakeholders from organisations actively involved in the collecting, managing, using and sharing of biological data in Scotland. From the start, discussions within the group and the wider recording community made clear that obtaining a complete and up-to-date account of species in Scotland is hampered by a declining pool of amateur expertise, complex data flows, and gaps in data collection and service provision. In November 2018 the SBIF Forum published the SBIF Review, which detailed 24 recommendations to improve biological recording in Scotland. In December 2019 a project proposal was submitted to the Scottish Government to deliver the recommendations. This was unsuccessful. However, in late 2022, NatureScot and The Scottish Government agreed to provide £580,000

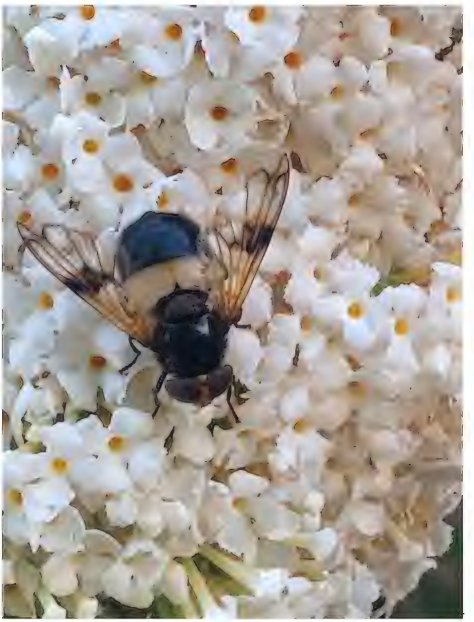

Fig. 4. Pellucid hoverfly (*Volucella pellucens*), Glasgow Botanic Gardens, 8th August 2021. (Photo: H. Murray)

over two years for the smaller BBD project. This funded project, hosted by the NBN Trust, commenced work in March 2023 and will help build the foundation of a stronger infrastructure for biological recording and biodiversity data in Scotland (Tansey, 2023).

It aims to develop the first steps in a national strategic approach to the collection, collation and sharing of biological data across Scotland and will continue to work alongside the SBIF advisory group and other key partners to address three key objectives: (1) the establishment of a National Hub that supports Local Environmental Records Centres (LERCs) and Recording Groups in Scotland; (2) the creation of a shared online data management and digital services system that can be used by LERCs, Recording Groups and other partners to streamline biodiversity data flows and help deliver data services in Scotland; and (3) the development of a more connected and better supported biological recording community in Scotland.

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APPENDIX. The number of taxa in UKSI (UK Species Inventory) for each organismal group, together with the number of taxa for which there are records in the GMBRC (Glasgow Museums Biological Records Centre) database, and the number of records of those taxa over several time periods. R6: Recorder 6 data software.

R6 Group	U.K. taxa	Taxa in GMBRC database	Records added pre-2003	Records added 2003-2013	Records added post-2013	Total records
Bacterium	399	1	1	5	211	217
Cyanobacterium	2	0	0	0	0	0
Archaean	0	0	0	0	0	0
Protozoan	516	1	12	4	1	17
Foraminiferan	144	1	9	0	0	9
Diatom	2,886	8	21	12	2	35
Slime Mould	555	14	7	8	34	49
Fungoid	421	4	1	7	5	13
Fungus	15,370	959	969	1,778	6,225	8,972
Lichen	2,391	267	662	197	222	1,081
Alga	2,985	14	4	8	45	57
Chromist	624	21	9	38	11	58
Stonewort	41	3	12	3	22	37
Liverwort	300	133	1,074	35	142	1,251
Hornwort	3	2	2	1	0	3
Moss	793	284	4,426	422	800	5,648
Clubmoss	12	4	113	33	9	155
Quillwort	5	1	1	0	1	2
Horsetail	19	10	2,701	262	316	3,279
Fern	126	38	7,740	1,112	695	9,547
Conifer	90	11	933	150	192	1,275
Ginkgo	1	1	0	0	1	1
Flowering plant	7,026	1,270	223,149	28,139	28,574	279,862
Mesozoan	21	0	1	0	0	1
Sponge (Porifera)	417	3	3	2	0	5
Placozoan	0	0	0	0	0	0
Coelenterate (=cnidarian)	536	11	15	8	10	33
Comb Jelly (Ctenophora)	4	1	0	1	0	1
Flatworm (Turbellaria)	113	10	120	97	47	264
Monogenean	1	0	0	0	0	0
Trematode	392	4	5	0	0	5
Tapeworm (Cestoda)	294	4	11	0	0	11
Ribbon Worm (Nemertea)	93	5	1	7	0	8
Rotifer	598	1	1	5	0	6
Gastrotrich	206	0	0	0	0	0
Loriciferan	3	0	0	0	0	0
Mud dragon (Kinorhyncha)	37	0	0	0	0	0
Gnathostomulid	12	0	0	0	0	0
Parasitic roundworm (Nematoda)	0	0	0	0	0	0
Roundworm (Nematoda)	791	4	9	11	3	23
Hairworm (Nematomorpha)	7	0	0	0	1	1
Thorny-headed worm (Acanthocephala)	2	0	0	0	0	0
Entoproct	51	0	0	0	0	0
Cycliophoran	1	0	0	0	0	0
Mollusc	1,966	170	2,524	2,797	2,087	7,408
Annelid	1,329	47	434	176	92	702
Pauropod	23	0	2	0	0	2
Symphylan	14	1	6	0	0	6
Acarine (Acari)	2,536	49	139	159	79	377

Spider (Araneae)	675	235	672	410	819	1,901
Harvestman (Opiliones)	31	18	76	143	196	415
Scorpion	0	0	0	0	0	0
False scorpion (Pseudoscorpiones)	24	8	21	2	4	27
Sea spider (Pycnogonida)	71	1	0	1	0	1
Crustacean	3,794	203	824	762	550	2,136
Millipede	69	38	92	306	187	585
Centipede	62	19	47	108	67	222
Proturan	11	0	13	0	0	13
Springtail (Collembola)	396	38	62	1	34	97
Two-tailed bristletail (Diplura)	12	1	2	0	0	2
Silverfish (Thysanura)	2	2	4	3	3	10
Bristletail (Archaeognatha)	7	2	7	0	1	8
Mayfly (Ephemeroptera)	53	18	46	199	155	400
Dragonfly (Odonata)	87	25	5,891	1,570	932	8,393
Stonefly (Plecoptera)	37	22	129	79	64	272
Orthopteran	48	16	194	51	85	330
Web-spinner (Embioptera)	0	0	0	0	0	0
Mantis (Mantodea)	1	0	0	0	0	0
Earwig (Dermaptera)	8	5	41	33	76	150
Cockroach (Dictyoptera)	26	7	39	1	4	44
Booklouse (Psocoptera)	91	26	67	10	20	97
Louse (Phthiraptera)	28	2	4	0	0	4
True bug (Hemiptera)	1,831	424	1,474	605	1,556	3,635
Thrips (Thysanoptera)	179	2	5	2	3	10
Stick insect (Phasmida)	5	0	0	1	0	1
Snakefly (Raphidioptera)	4	0	7	0	0	7
Alderfly (Megaloptera)	3	2	21	20	33	74
Lacewing (Neuroptera)	72	29	112	42	66	220
Beetle (Coleoptera)	3,957	1,936	25,003	2,051	4,804	31,858
Stylops (Strepsiptera)	16	2	2	0	0	2
Scorpion fly (Mecoptera)	4	3	30	33	45	108
Flea (Siphonaptera)	87	20	33	19	1	53
Caddis fly (Trichoptera)	208	113	588	326	525	1,439
Butterfly	116	49	15,484	26,115	41,450	83,049
Moth	2,780	1,297	66,074	31,512	86,857	184,443
True fly (Diptera)	7,240	1,188	6,070	5,321	6,635	18,026
Hymenopteran	8,148	549	1,351	1,914	6,373	9,638
Priapulid	4	0	0	0	0	0
Spoon worm (Echiura)	8	0	0	0	0	0
Peanut worm (Sipuncula)	25	0	0	0	0	0
Waterbear (Tardigrada)	57	0	0	0	0	0
Tongue worm (Pentastomida)	0	0	0	0	0	0
Beardworm (Pogonophora)	11	0	0	0	0	0
Horseshoe worm (Phoronida)	5	0	0	0	0	0
Bryozoan	320	6	9	1	0	10
Lampshell (Brachiopoda)	18	1	0	1	0	1
Echinoderm	158	10	8	16	1	25
Arrow worm (Chaetognatha)	20	0	0	0	0	0
Acorn worm (Hemichordata)	13	0	0	0	0	0
Tunicate (Urochordata)	124	2	0	3	0	3
Lancelet (Cephalochordata)	1	0	0	0	0	0
Jawless fish (Agnatha)	5	3	16	4	3	23
Cartilaginous fish (Chondrichthyes)	0	0	0	0	0	0
Bony fish (Actinopterygii)	596	36	287	195	60	542

Amphibian	7	5	1,505	2,108	1,698	5,311
Reptile	7	4	849	124	129	1,102
Bird	778	299	33,874	30,886	285,796	350,556
Marine mammal	39	12	31	28	26	85
Terrestrial mammal	69	33	2,332	2,852	7,669	12,853

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Further evidence of breeding populations of lime hawk-moth *Mimas tiliae* (Lepidoptera: Sphingidae) in Glasgow, Scotland

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In a recent note Payne (2020) described finding a caterpillar of lime hawk-moth (*Mimas tiliae* (Linnaeus, 1758)) in Jordanhill, Glasgow, and mentioned an earlier sighting of a mating pair in Glebe Street, Renfrew, Renfrewshire.

In the summer of 2023, there were further sightings of adults and a larva in Glasgow. One of the adults was seen on 11th June on the north edge of Victoria Park, within 200 m of Payne's larva sighting in 2019. The latter mentioned that there are some 100 mature limes (*Tilia* spp.) in that part of the park, which may well be the breeding-ground. The other adult was found by Alice Howlett some 2 km to the east: in Dundonald Road, Dowanhill, on 9th June (Fig. 1); lime trees are frequent in that area. The larva (Fig. 2) was sighted by Ruth Addie on 11th August in a car-park at Queen Elizabeth University Hospital, Glasgow, which is south of the Clyde, and again some 2 km distant from the Jordanhill sightings, and moreover some 3 km from Glebe Street, Renfrew, where the original mating pair were seen in 2016. There are limes present around the car park, but the larva was assumed to be looking for pupation site, which could have been quite a challenge in a hard-surfaced car park.

Payne (2020) gives the historical background to this species in the west of Scotland, and suggests that the sightings in recent years constitute strong proof of successful colonisation in this area. The 2023 sightings give further weight to this suggestion and imply that there are at least two populations present, north and south of the river. This is the only area in Scotland where such breeding populations exist (T. Prescott, pers. comm.). However, the National Biodiversity Network (NBN) Atlas (NBN, 2023) shows, in addition to the "unconfirmed" record on the Ayrshire coast mentioned by Payne, a larva seen by a Countryside Ranger in Edinburgh in 2010, though the associated photo indicates that it was a humming-bird hawk-moth (*Macroglossum stellatarum*), and so this record should be ignored (M. Cubitt, pers. comm.).

Having researched the Ayrshire record further, I can add that it was described by a Countryside Ranger at Culzean Country Park, on 8th May 2015 (NBN, 2023); they provided a photograph of the moth, and so there is no reason to doubt the report (R. Miller, pers. comm). There are no records of this moth in any of the three Rothamsted traps at Culzean, nor in any other Scottish Rothamsted trap (C. Shortall, pers. comm.). It therefore seems likely to have been an isolated occurrence, though, as it was recorded in a car park at a popular tourist destination, the possibility that it was imported, perhaps unwittingly, from England cannot be ruled out. The Renfrew sighting is in the vice-county of Renfrewshire (VC76); the locations of the other Glasgow occurrences are all in Lanarkshire (VC77). There was a further sighting in VC77 in 2023: an adult in a lighted greenhouse in Bishopbriggs. This, being an

Fig. 1. Lime hawk-moth (*Mimas tiliae*), Dundonald Road, Dowanhill, Glasgow, 9th June 2023; wingspan *ca.* 60 mm. (Photo: Alice Howlett)

Fig. 2. Lime hawk-moth (*Mimas tiliae*) larva, Queen Elizabeth University Hospital, Glasgow, 11th August 2023; body length *ca.* 60 mm. (Photo: Ruth Addie)

isolated record of an adult, cannot be taken as evidence of breeding in that area, though there are lime trees present, as it may be a vagrant.

The VC77 records described here will be submitted to the National Moth Recording Scheme early in 2024. The 2023 records, except that at Bishopbriggs, were also submitted to iRecord or iNaturalist by the observers themselves. All these records will appear on the NBN Atlas in the foreseeable future.

I am grateful to Mark Cubitt for investigating the Edinburgh record shown on the NBN Atlas, to Rob Miller (NTS) and Chris Shortall (Rothamsted Research) for information on the Culzean record, to Tony Payne for his excellent introductory account of the moth, to which I have frequently alluded in this note, and to Alice Howlett and Ruth Addie for kindly allowing me to use their photos.

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Records of the chrysophyte alga *Synura uvella* Ehrenberg 1834 from Loch na Thull and Loch Merkland, Sutherland, Scotland

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Synura is a genus belonging to the group of algae known as chrysophytes ("golden plants"), which are single-celled or colonial flagellates. They possess unequal flagella with a characteristic brown fucoxanthin chloroplast pigment giving them a golden-brown colour when examined live. *Synura* cells are surrounded by silicaceous scales, examination of which is the most important means of identifying them. Although some species can be identified using light microscopy, for most chrysophyte taxa scanning or transmission electron microscopy is necessary (Kristiansen & Preisig, 2007).

Synura spp. are widely distributed but not common, and are mostly undocumented (Reynolds & Irish, 2000; John *et al*., 2011). John *et al*. (2011) detailed 18 known species at the time of publication (with six species recorded from the British Isles), whereas the current information details as many as 57 species world-wide (Guiry & Guiry, 2024). *Synura* spp. and chrysophytes in general occur mainly in oligotrophic and mesotrophic waters, usually in spring following periods of nutrient depletion. Their distribution is related to pH such that where there is a plentiful supply of dissolved carbon dioxide, chrysophytes will be more abundant, whereas in waters that are buffered by bicarbonate and the pH is elevated due to higher phytoplankton production, chrysophytes are less common (Reynolds, 1997). Many chrysophytes can be a nuisance when in bloom and impart a fishy odour and unpleasant taste to water.

I report here that *S. uvella* has been recently identified with certainty from two Scottish Lochs - Loch na Thull and Loch Merkland, both Sutherland (Fig. 1). The records were from a sub-surface sample collected during July 2023 from Loch na Thull, and during September from Loch Merkland 2023, using a throw sampler. Samples were preserved with Lugol's solution in the field, and analysed later by the author using an inverted microscope following standard procedures (Brierley *et al*., 2007). Identification was based on colony and cell appearance, following keys in John *et al.* (2011), Kristiansen & Preisig (2007), and Tikkanen (1986).

Fig. 1. Spiny colony of *Synura uvella*, Loch Merkland, Sutherland, Scotland, September 2023. Lugol's preserved sample. The cells are 20 x 8 µm in size. The black line is part of an eyepiece graticule. (Photo: J. Krokowski)

S. uvella has been rarely reported or documented from the British Isles, although many other chrysophytes have been widely reported from Scottish freshwater lochs as part of loch monitoring by the Scottish Environment Protection Agency (SEPA). *S. uvella* was recorded from England by Harris & Bradley (1956) and from North Wales by Kristiansen (1979) who used electron microscopy of the silica scales for identification purposes. Regarding previous Scottish records, *S. uvella* was present in samples collected by Bradley (1966) "from ponds, ditches and flood water" near Edinburgh and there is a 2006 record from the south end of Loch Lomond whose source is SEPA's *River Macroinvertebrate Data for 2005 and 2006* (National Biodiversity Network, 2024).

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Reesa vespulae (Coleoptera: Dermestidae): a rare synanthropic beetle found in a Glasgow tenement

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Beetles in the family Dermestidae are synanthropic, i.e. they are commonly encountered in and around human habitations, resulting in their reputation as household pests. While some species can be problematic, many seldom occur in large numbers and at least seven of the 39 species established in the U.K. (two additional species are non-established introductions) are primarily recorded in the wild (Duff, 2020). Due to their habit of feeding on food products, textiles and museum specimens, new species of dermestid beetles are highly likely to establish themselves as introductions in the U.K.

Reesa is a monotypic genus of dermestid beetles. *Reesa vespulae* is found widely distributed in the Nearctic region and is an established introduced species in the U.K. (Duff, 2020). It appears to be predominantly synanthropic and has been found among seed, fungi and insect collections in museums and universities (Peacock, 1993). The species was originally described in Minnesota, U.SA. (Milliron, 1939) in a nest of the wasp *Dolichovespula arenaria*, albeit one that had been housed in a university laboratory for several years. It is possible that it has shifted from feeding on the carcasses and waste of social Hymenoptera, in the warmth of a nest, to the warm conditions and abundant food in buildings. Although it is not clear where this species originated, there appear to have been multiple introduction events that spread it to temperate areas spread around the globe, from America to Europe, Korea, Japan and even as far as New Zealand (Nardi, 2021). Female adults and larvae have been well described (Milliron, 1939; Kadej *et al*., 2017), although no males have ever been found. In initial experiments, Milliron (1939) hatched pupae into adults that laid viable eggs without mating, suggesting that *Reesa vespulae* can reproduce by parthenogenesis.

There are no records for this species in Scotland listed in the National Biodiversity Network (NBN) Atlas, with only 12 records in total for the rest of the U.K. There are nine records since 2011 listed on iRecord not all of which overlap with the NBN records (NBN, 2024; iRecord, 2024). In addition, Peacock (1993) mentions records for Dunfermline (Fife) and Perth (Perthshire). National Museums Scotland has four specimens in its collections found in Edinburgh in 1991, and there is a record from Dunfermline (28th May 1981) on the Scottish Insect Records Index (SIRI).

The specimen illustrated here (Fig. 1) was found alive in a Glasgow tenement building on 5th August 2022, indoors near a window, and a second individual was found shortly afterwards. They were identified using the keys in Duff (2020). None have been found at this location since, although several other synanthropic beetle species have been recorded: *Dermestes peruvianus, Anthrenus verbasci* and *Niptus hololeucus*. As larval stages have previously been known to destroy museum specimens, it is important to monitor for this beetle when transferring collections (Kadej *et al*., 2017).

Fig. 1. Specimen of *Reesa vespulae* collected indoors in a tenement flat in Glasgow, Scotland, 5th August 2022. (A) Lateral view (mounting pin present). (B) Dorsal view (mounting pin absent). Both images were produced by focus-stacking (combining photographs of the subject focused at different focal planes). The specimen is *ca.* 3.5 mm in length and was stored in 70% ethanol before pinning. (Photo: E. Parry)

I would like to thank Richard Weddle for helping with the identification, Jeanne Robinson, Hunterian Museum (University of Glasgow), for kindly helping with queries on specimen storage and preparation, and Ashleigh Whiffin, National Museums Scotland, for providing information on historical records.

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First record of the salmon salad fungus *Guepinia helvelloides* in the Glasgow area, Scotland

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The parks of Glasgow have long been known for hosting a variety of interesting fungi (Marshall, 1979). Since 2010 the Clyde and Argyll Fungus Group (CAFG) has undertaken numerous fungal surveys in parks and country parks around the Glasgow area, adding many new fungi records which have been submitted to the Fungal Records Database of Britain and Ireland (FRDBI). Some of the more unusual finds by CAFG members within the environs of Glasgow have been highlighted in a series of notes in *The Glasgow Naturalist* (O'Reilly, 2018-2020, 2022; O'Reilly & Mitchell, 2019; O'Reilly & Taylor, 2023).

On 11th November 2022, an unusual looking fungus comprising a clump, about 10 cm in diameter, of concentric fleshy apricot-coloured lobes was found by RM in the Dams to Darnley Country Park, on the southern outskirts of Glasgow. The fungus was found growing amongst leaf litter and exposed tree roots under a large goat willow (*Salix caprea*). This was located in a wooded area east of the Brock Burn (NS5267458842) and just a short walk north-west of the park entrance at Corselet Road/Brock Burn culvert. A photograph was sent to CAFG member Gill Smart who determined it as a salmon salad fungus (*Guepinia helvelloides*) based on its distinctive shape and colouration (Fig. 1).

The site was visited by CAFG member MOR almost a month later on 10th December and the fungus clump was still present and relatively intact, albeit partly frozen by an intervening cold snap. The characteristic form and apricot hue of the fruiting body was still evident allowing confirmation of the identification. Around a year later on 3rd October 2023, RM revisited the site and discovered that the salmon salad fungus had reappeared at the exact same spot.

The salmon salad fungus is a relatively infrequent species in the British Isles. There are just over 200 records with most scattered across England and Wales, only three records from Ireland, and a dozen from Scotland. The previous finds nearest to the Glasgow area are to the north, from Perthshire in Doune, 2008, and Strathyre Forest, 2013; a single record from Larkhall, Lanarkshire, in 2019; and, further south, two finds on CAFG forays in Ayrshire at Shewalton Moss in 2020 and Galston in 2022 (FRDBI, 2023). There is also a find from Loch Fad on the Isle of Bute, Firth of Clyde in 2012.

Fig. 1. Salmon salad fungus (*Guepinia helvelloides*) from Dams to Darnley Country Park, Glasgow, November 2022. The £2 coin is 12.8 mm in diameter. (Photo: R. Mason)

Salmon salad fungus is a distinctive species with its brightly coloured fruit bodies and rubbery texture. It usually has a salmon pink colouration, hence its common name, but may also be apricot-coloured, as in this new find, providing the alternative common name of apricot jelly. However, despite its name, the species, although edible, even when raw, is rather bland and of little culinary interest. Although easily identifiable it could be confused with the hare's ear fungus (*Otidea onotica*). The scarcity of salmon salad fungus means that it is only figured in the more comprehensive field guides (e.g. Buczacki *et al.*, 2012) and hence may go unrecognised by many casual foragers. However, many foragers now browse the internet to help identify fungi and this species is well described and illustrated on the First Nature website (First Nature, 2023) where it can be easily distinguished from the hare's ear fungus. This new find in a suburban setting suggests that salmon salad fungus might be more widespread in Scotland than

previously realised and salmon salad, or apricot jelly, should now be considered "on the menu" of Scottish fungi.

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The Edinburgh and Glasgow copies of Elias Fries's *Scleromyceti Sueciae*

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Elias Magnus Fries (1794-1878) is considered to be the "Father of Mycology" and his *Systema Mycologicum* (Fries, 1821-32) is regarded as the starting point for the nomenclature of most fungal groups. Amongst his other important achievements is *Scleromyceti Sueciae*, which was produced in the form of "exsiccati" – collections of dried herbarium specimens published in duplicate sets. Fries issued these from Lund, Sweden during the years 1819-1825 and their specimens form part of the type for the species described in his *Systema Mycologicum* (Hutchinson, 1964). In this contribution I provide information on two copies of *Scleromyceti Sueciae* that are currently located in Scotland.

During the preparation of a revision of the Reverend J. Stevenson's *Mycologia Scotia* (Stevenson, 1879) and a review of the mycological collections (fungarium) of the Royal Botanic Garden Edinburgh (RBGE), it became apparent that also housed in RBGE was a large number of Elias Fries's collections from *Scleromyceti Sueciae*, made by him or under his direction. The material in RBGE had been cut from its original folders, as is the case for many other copies located in Europe, and each species was filed in the fungarium under its current name.

Scleromyceti Sueciae was issued in 34 "Decads" bound into nine "Fascicles". As recounted by Holm & Nannfeldt (1963), Professor C.L. Shear (1865-1956), who had visited Uppsala, Sweden in 1905 whilst making a special study of Fries's publication, found eight fascicles made up of Decads I-IV in RBGE. He considered that the Edinburgh material was part of a second edition of Fries's work, not as important, but of considerable note. It appears to have been offered for sale in the autumn of 1834 and is not as complete as the first edition, as Fries did not have printed labels for the collections or used old ones. It appears to have been prepared (possibly in haste) before Fries left Lund for a position in Uppsala. Holm & Nannfeldt (1963) include a page of handwriting which had indicated to Shear that some of the specimens had been labelled by a "secretary", later named as "Wallenberg".

The second edition, as exemplified by the Edinburgh material, was simpler than the first and the specimens were glued to loose pieces of paper 10 x 8 cm in size. Specimens 1-340 apparently were issued with the intention of duplicating the original edition; 341-460 had not been distributed before and appear also to have been labelled by Wallenberg. Holm & Nannfeldt (1963) published an appendix to the title pages for Fascicles 2-4, a checklist, and a commentary on the latter checklist, as well as the correspondence with Shear. Holm & Nannfeldt (1963) had not been aware of the existence of a second edition and it was only through Shear's investigation and diligence that such an edition became known. In addition, Holm, Nannfeldt and Shear were unaware that a *first* edition was located in Scotland.

In 1958, John Walton (1895-1971), Regius Professor of Botany at the University of Glasgow from 1930 to 1962, found an uncut first edition copy of *Scleromyceti Sueciae* amongst artifacts left by his predecessors (Hutchinson, 1964). This may have been purchased by Professor George Walker-Arnott (1845–1867), who succeeded John Hutton Balfour (1808-1884) as Regius Chair of Botany, and who had already made strong connections with Sweden, having been awarded the King Gustaf Medal. The publication was in a wooden cabinet with eight shelves. Even though he was a palaeobotanist by training, Professor Walton realised the significance of this collection and that specimens in copies of this work formed part of the descriptions on which many of the species are based, which made it one of the most important mycological collections held in Scotland.

Some four years later, Stephen Hutchinson, a mycologist in the same Department of Botany, produced a brief account of the discovery of this uncut first edition for *The Glasgow Naturalist* (Hutchinson, 1964), indicating that, if anyone wished to see it, they would require permission from the Regius Professor. He noted that, though lacking one fascicle, it was one of the best preserved first editions of this important scientific work.

In 2001, the Department of Botany's Bower Building suffered a devastating fire, which destroyed most of the structures of the department and their effects. I was curious to know what became of the copy of *Scleromyceti Sueciae*. With the help of Richard Weddle, Glasgow Natural History Society, I eventually discovered that the cabinet had survived and was located in Glasgow Life Museums, as confirmed by its curator, Keith Watson (Fig. 1). It transpired that, as part of the university's restructuring of life-sciences during the 1990s, the Department of Botany's large herbarium had been moved from the Bower Building to the Graham Kerr Building (which had housed the former Department of Zoology). Later in 2007, the British herbarium specimens were transferred to Glasgow Life Museums, with overseas specimens moving to the RBGE. The Fries cabinet was apparently included in the transfer to Glasgow Life Museums, though its significance was not then appreciated.

Fig. 1. Cabinet housing the Glasgow copy of *Scleromyceti Sueciae*. (Photo: © CSG CIC Glasgow Museums Collection)

Fig. 2. Title page of the Glasgow copy of *Scleromyceti Sueciae*. (Photo: © CSG CIC Glasgow Museums Collection)

Fig. 3. Specimen of "*Sph.* [*Sphaeria*] *conspersa*" (now *Tympanis conspersa*) from the Glasgow copy of *Scleromyceti Sueciae*. (Photo: © CSG CIC Glasgow Museums Collection)

The Glasgow copy of *Scleromyceti Sueciae* (Figs. 2 and 3) is composed of sheets approximately 21 x 16 cm in size and bound with notes and indices in the original grey paper cover. It consists of the following: Fascicle 1, Decads 1-IV (1819); Fascicle 2, Decads V-VII (1820); Fascicle 3, Decads VIII-XI (1820); Fascicle 4, Decads XII-XIV (1820); Fascicle 5, Decads XV-XVIII (1821); Fascicle 6, Decads XIX-XXII (1821); and Fascicle 8, Decads, XXVIII–XXX (1822). Fascicle 7 is missing and was not found when Professor Walton discovered the copy. As there have been several moves of the Department of Botany since the time of Professor Walker-Arnott, it may be permanently lost. Hutchinson (1964) found that some specimens were missing: No. 36 *Sphaeria complanata* (now *Calophoma complanata*), No. 88 *Lophium excipuliforme*, No. 120 *Sphaeria pulvis-pyrius* (now *Melanomma pulvis-pyrius*), No. 185 *Sphaeria microstoma* (now *Cytospora populina*), and No. 274 S*phaeronema pyriforme*, a species not recognized in the Index of Fungi (https://www.cabi.org/publishing-products/index-of-fungi/).

Keith Watson has data-based all the specimens in the Decads under their original names and this will be available on Glasgow Life Museums' website (https://collections.glasgowmuseums.com/mwebcgi/mweb?request=home).

I am grateful to Maggie Reilly, Niki Russell, Richard Weddle and Giovanna Vitelli for the investigations made on my behalf, and to Keith Watson who has been a great help throughout in offering suggestions and support.

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An unusually dense bloom of the cyanobacterium *Gloeotrichia echinulata* in Loch Watten, a Scottish highland loch, during July 2023

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Loch Watten is a large (surface area 373 ha), very shallow (mean depth 2.6 m, maximum depth 3.7 m), high alkalinity, low altitude loch in Caithness, north mainland Scotland, with a predominantly improved and rough grassland catchment area of 5,578 ha (Fig. 1). There are two inflows to the north of the loch with an outflow to the Wick River in the south of the loch, draining for about 12 km to the North Sea at Wick.

Fig. 1. Location and catchment of Loch Watten, Scotland. Lake polygon geometry in Great Britain is based on Ordnance Survey data and contains public sector information licensed under the Open Government Licence v3.0 (Hughes *et al.*, 2004).

Loch Watten is monitored regularly by the Scottish Environment Protection Agency (SEPA) for several determinands as part of the EU Water Framework Directive (WFD) requirements, with data available from 2002 onwards. No data or very limited data were available between 2020 and 2022. Although the ecology of the loch is reported as being at 'Good' ecological status, with the phytoplankton biological quality element also at 'Good' status, the overall ecological status is 'Moderate', due to a downgrade for total phosphorus (TP).

Total phosphorus concentrations indicated a discernible increase in concentrations over 2002-2019, although in the period 2012-present concentrations fluctuated seasonally but have not shown a discernible further increase (Fig. 2A). The average TP concentrations for 2018 and 2019 were 57.63 µg L^{-1} TP and 59.5 µg L^{-1} TP respectively, highlighting 'Moderate' status under WFD and very close to the 'Moderate/Poor' ecological class WFD boundary which is 62 µg L^{-1} TP. Peaks in TP were generally visible during winter periods (2013, 2014 - highest 0.2 mg L^{-1} TP, and 2016), but peaks were also recorded during May and August 2016, November 2017 and in March 2018 and 2019. Minima were generally observed over spring and summer.

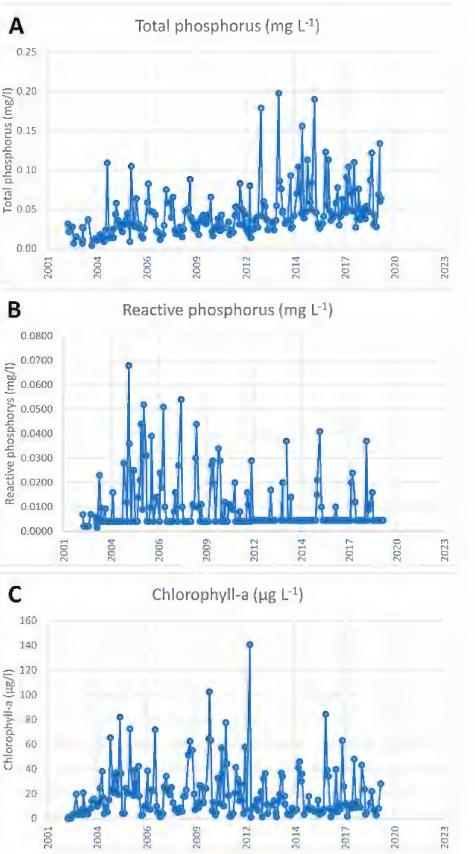

Fig. 2. Total phosphorus (A), reactive phosphorus (B) and chlorophyll-a (C) 2002-2019, Loch Watten, Scotland.

Reactive phosphorus concentrations indicated a slight decrease in concentrations over the same period (2002-

2019) with peaks also recorded in winter and late summer (Fig. 2B).

Spring and summer pulses may be indicative of nutrient re-release from sediments back into the overlying water. During the main phytoplankton growing period in late summer/autumn concentrations were at the limit of detection, potentially highlighting P-limitation for phytoplankton. Other factors may also limit phytoplankton growth. Potential for nitrogen limitation may be assessed using combination of several thresholds; when total oxidised N are <10 mg L^{-1}, dissolved inorganic N <25 µg L^{-1}, nitrate N concentrations <5 µg L^{-1}, and N:P ratios <16 and <10. Examining such trends in Loch Watten (not shown) highlighted periods in late summer when the TON:TP ratios were <10 and total oxidised N concentrations <0.1 mg L^{-1}, with no periods when nitrate concentrations were <5 µg L^{-1}. These may also suggest N-limitation during late summer in Loch Watten.

Phytoplankton biomass as measured by chlorophyll-a highlighted a seasonal pattern with peaks during spring and autumn, with no discernible change in phytoplankton biomass over the period 2002-2019 (Fig. 2C). Maximum chlorophyll-a of 140 µg L^{-1} was recorded during June 2012, but recent maxima were lower (43 µg L^{-1} in August 2018) with average concentrations of 17 µg L^{-1} chlorophyll-a in 2018 and 14 µg L^{-1} chlorophyll-a in 2019, respectively.

Although there are no details on which phytoplankton groups dominated during spring, available phytoplankton data over the growing season only (July-September) from 2015, 2017 and 2019 highlighted green algae *Coelastrum* spp., *Pediastrum* spp. and *Botryococcus* spp., and cryptophytes *Cryptomonas* spp. and *Rhodomonas* spp. as dominant taxa. Cyanobacteria *Anabaena* spp. and *Aphanizomenon* spp. were also abundant, with *Gloeotrichia* recorded as present and abundant.

In 24th July 2023 reports were received by SEPA of a large amount of foam at Loch Watten (Fig. 3). A water sample was subsequently taken and submitted to SEPA laboratory for analysis. The sample was received three days later. Large visible dark olive macroscopic colonies, mostly 1 mm in diameter were evident (Fig. 4). Microscopic examination identified these as a cyanobacterium - *Gloeotrichia echinulata* - with a recorded biomass of 12,348 mm^3 L^{-1} ($550x10^6$ cells mL^{-1}, 22,919 colonies mL^{-1}). Signs of the bloom breaking down were evident three days later (Fig. 5). *G. echinulata* were also recorded on the 28th July 2023 approximately 12 km downstream of Loch Watten in the Wick River, floating towards the sea.

G. echinulata is a nitrogen fixing, filamentous cyanobacterium forming spherical colonies which may reach many mm in diameter. It has been frequently recorded in analysis carried out by SEPA across Scotland (Krokowski, 2022) as part of the guidance for assessing and minimising risk to public health as outlined by the Scottish Government (Scottish Government, 2012).

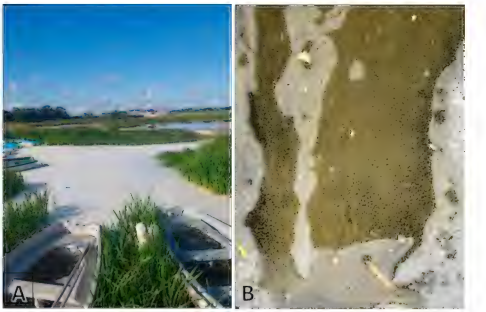

Fig. 3. Extensive *Gloeotrichia echinulata* foam coverage at Loch Watten, Scotland, 24th July 2023. (A) Whipped-up foam. (B) Macroscopic colonies in water. (Photos: E. Summers)

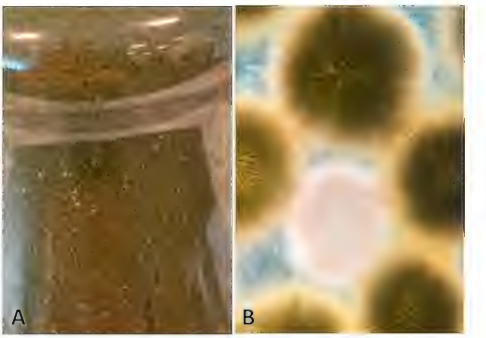

Fig. 4. *Gloeotrichia echinulata* photographed 27th July 2023. (A) Large colonies, including white colonies, in sample bottle received in SEPA laboratory. (B) Microscopic view of colonies. Colonies shown are *ca.* 0.75–1.0 mm in diameter. (Photo: J. Krokowski)

Fig. 5. Signs of bloom breaking down, Loch Watten, Scotland, 27th July 2023. (Photo: M. Nicolson)

Four *Gloeotrichia* species have been recorded from the British Isles in fresh and slightly brackish waters (John *et al.*, 2011), with solely *G. echinulata* recorded from

freshwater lochs in Scotland. It is unlikely *G. echinulata* would survive in a river environment such as Wick River due to high flow velocity. However, other *Gloeotrichia* species, such as *G. natans*, have been commonly found in a variety of aquatic habitats, including rivers, where *G.* cf. *natans* was found growing on rocks (Gabyshev *et al.*, 2023).

Mainly dark-green olive colonies were observed. However, there were a few white colonies. These are called "ghost colonies" (C.C. Carey, pers. comm.) and are likely to be senescing due to viruses, grazing, or other mortality events.

A summary of global cyanobacterial poisonings, including those attributed to *Gloeotrichia* is provided by Svircev *et al.* (2019), highlighting cyanobacteria to have the potential to produce a large variety of secondary metabolites, including hepatotoxins, neurotoxins, cytotoxins, dermatoxins, enzyme inhibitors and antimicrobial compounds, which pose a threat to human and animal health. *Gloeotrichia* was shown to be not lethally toxic to mice from studies by Leeuwangh *et al.* (1983), whereas the first detected report of cyanotoxin microcystin-LR from *Gloeotrichia* was provided by Carey *et al.* (2007). On this occasion, toxicity testing carried out on bloom material from Lake Watten highlighted that material was non-toxic (C. Edwards, pers. comm.).

G. echinulata colonies form through radial arrangement of filaments and look like hairy balls, clearly visible and relatively distinct to the naked eye. *Gloeotrichia* form specialised cells – akinetes – which settle on sediments following the end of their growth period and possesses a unique life strategy as they can subsequently germinate from sediments during the following summer. Carey *et al.* (2008) highlighted recruitment from shallow (2 m) sediments but not deep (>5 m) sediments, highlighting an important transfer pathway of nutrients (especially P) from sediments to open water (Karlsson-Elfgren *et al.*, 2003). Germination is triggered by light, followed by growth on the sediment before colonies develop gas vesicles and can float upwards towards the surface (Barbiero, 1993), where they can form dense growths, i.e. blooms. Once in the open water, *Gloeotrichia* can utilise the internally stored, sediment-derived P for their growth, and this recruitment of P-rich colonies was calculated to account for two thirds of the total internal P loading between mid-July and mid-August in studies by Istvánovics *et al.* (1993), and represented an important transfer pathway for P.

Pitois *et al.* (1997) detailed a *Gloeotrichia* bloom in Antermony Loch near Auchenreoch, East Dunbartonshire in central Scotland, during August 1994. Antermony Loch is a small (14 ha), shallow loch with mean depth 4.1 m. Peaks of 10,000 cells mL^{-1} were recorded in Antermony Loch with highest levels of particulate inorganic and particulate organic P recorded when the bloom reached its maximum density. This contrasts with a *G. echinulata* concentration recorded in Loch Watten in July 2023 of $550x10^6$ cells mL^{-1} . Studies in the U.S.A. (Pratt & Holme, 2016) recorded maximum concentrations of over 1,000 colonies L^{-1} in high-nutrient systems, with concentrations at some recorded as between 192 and 250 colonies L^{-1}. Variability between the years was attributed to weather patterns and the authors also suggested increase in *Gloeotrichia* in lower-nutrient systems in the U.S.A. could be due to climate change. This contrasted with 22,919 colonies mL^{-1} recorded from Loch Watten during July 2023.

In Scotland, with increasing warmer temperatures, particularly in shallow and very shallow lochs, effects of climate change on water quality of standing waters may include an increase in algal blooms with higher risk of potentially harmful cyanobacterial blooms and toxins (May *et al.*, 2022).

To help provide a comprehensive picture of cyanobacteria occurrence in Scotland, visible blooms should be reported to SEPA and Local Authorities and the *Bloomin' Algae* app (available at: https://www.ceh.ac.uk/our-science/projects/bloomin-algae) should be used to help record bloom incidence.

I would like to thank the anonymous reviewer for comments and the Editor for his detailed comments and amendments.

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A remarkable occurrence of orache moth *Trachea atriplicis* (Lepidoptera: Noctuidae) in Glasgow, Scotland

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At a moth-trapping session the night before a public event at Hamiltonhill Claypits Local Nature Reserve (LNR), Glasgow, Scotland in July 2022, among a small and otherwise unremarkable catch was a single specimen of orache moth *Trachea atriplicis* (Linnaeus, 1758) (Fig. 1).

Fig. 1. Orache moth (*Trachea atriplicis*), Hamiltonhill Claypits, Glasgow, Scotland, 15th July 2022. (Photo: R.B. Weddle)

In the 19th century this species was resident in south-east parts of England and was last recorded as such in the Fens of East Anglia in 1915. It is now resident only in the Channel Islands and elsewhere in the U.K. it is regarded as rare migrant (Waring, 2017). This is the first Scottish record (confirmed as such by R. Leverton, pers. comm.). According the National Biodiversity Network (NBN) Atlas, the most northerly prior record is at Broad Green, Liverpool in July 2009 (NBN, 2023), but there are also records from Yorkshire in 2009 and 2020, the latest and most northerly being at Askham Bryan on the outskirts of the City of York, some 300 km distant from Hamiltonhill Claypits (Yorkshire Moths, 2023). I am grateful to the anonymous reviewer of this article for pointing out that a further significant aspect of this sighting is that it is inland, whereas most previous British sightings have been coastal, as one would expect for a migrant species.

As the name implies, the larvae feed on orache (*Atriplex* sp.), as well as goosefoot (*Chenopodium* sp.) and other herbaceous plants (Waring, 2017).

The trap was situated in the secure yard belonging to Scottish Canals, immediately adjacent to the Claypits LNR at NS58536721 in VC77 (Lanarkshire). The record has been submitted to the National Moth Recording Scheme and Glasgow Museums Biological Records Centre. Records submitted to iNaturalist by other attendees at the event are duplicates of this one individual.

I am grateful to Scottish Canals for allowing me to use the yard for moth-trapping, to Tony Payne for alerting me to the significance of the find, and to Richard Walker for details of the Liverpool sighting.

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The unusual alga *Gonyostomum semen* (Ehrenberg) Diesing 1866 and its occurrence in Scottish freshwater lochs

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Gonyostomum is a genus of freshwater algae in the class Raphidophyceae, phylum Heterokontophyta (Guiry & Guiry, 2024). Although five species have been described from Europe (Koreiviene *et al*., 2012), only one – *G. semen* – has been recorded from the British Isles (John *et al.*, 2011) with the first record reported in 1933 (Malin Smith, 1933).

Living *G. semen* cells are motile, bright green in colour, ovoid in shape with a rather flattened body, and are easily recognised. The cells possess two flagella, one pointing forward and the other, when seen from the side, pointing backward, although in the photographs only one flagellum can be clearly seen (Fig. 1). The cells lack a cell wall, but several discoid chloroplasts are visible together with a number of rod-like trichocysts. Trichocysts, also known as muciferous bodies, are of unknown function, and can be ejected under stress. This can result in water bodies becoming slimy and causing skin irritation (Cronberg *et al*., 1988).

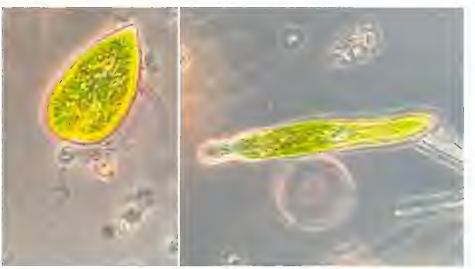

Fig. 1. Live *Gonyostomum semen* cells, Loch Merkland, Sutherland, 25th October 2023. Left image shows top view of cell, which is 70 µm long and 30 µm wide. Right image shows side view of cell, which is 12 µm deep. (Photos: J. Krokowski)

Analysis carried out by the Scottish Environment Protection Agency (SEPA) requires all samples to be preserved with Lugol's solution with enumeration carried out using the standard methodology (Brierley *et al*., 2007). During preservation, trichocysts may be ejected and, because they lack a cell wall, cells may disintegrate, lose their unique identification features, and become difficult to identify. Examples of preserved burst cells are shown in Fig 2.

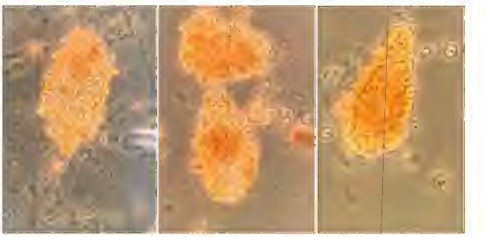

Fig. 2. Examples of burst *Gonyostomum semen* cells from Lugol's preserved samples, Loch Merkland, , Sutherland, September 2023. Cells are approximately 50-70 µm long. The darker round object in the middle image, lower cell, is the cell nucleus. The black lines are part of an eyepiece graticule. (Photos: J. Krokowski)

G. semen was noted in Swedish lakes in the 1940s and in Norwegian and Finnish lakes in the 1970s, and is generally found in humic waters with increasing occurrence reported in recent decades mainly from Scandinavian and Baltic countries (Hagman *et al.,* 2015). A rapid increase of *G. semen* has been linked to climate change (increasing spring, autumn and annual temperatures) (Rohrlack, 2020) and to anthropogenic activities in the catchments causing increasing browning and inputs of both organic matter (dissolved organic carbon - DOC) and nutrients, which are creating favourable conditions for this species (Hagman *et al*., 2015, 2019, 2020). Dispersal of the alga can also be driven by autumnal migratory birds (Rengefors *et al.,* 2021).

In Scotland, *G. semen* has been occasionally recorded in high abundance from a small number of freshwater lochs (Table 1). These are monitored by SEPA mainly during July, August and September as part of the freshwater loch monitoring programme, although no records were evident prior to 2009 when detailed loch monitoring and analysis began.

The Scottish records of *G. semen* are all from lowland, humic waters and all, apart from Loch Awe north basin, Argyll and Loch Ness, Invernessshire, are shallow water bodies, with relatively high colour and DOC concentrations. The most northerly record is from Loch Hempriggs, Caithness, and the most southerly from Loch Ken, Dumfries & Galloway. Although no single mechanism has been demonstrated for increases in DOC in waters in the U.K. (Worral & Burt, 2007), increasing surface temperatures could potentially lead to increasing microbial activity, enhanced decomposition and increased DOC production, potentially leading to more favourable conditions for *G. semen* (Hagman, 2020; Rohrlack, 2020).

Water body	Year	Month	Biovolume ($mm^3 L^{-1}$)
Loch Insh, Invernessshire	2009	July	<0.01
	2009	September	0.06
	2011	August	<0.01
Gartmorn Dam, Clackmannanshire	2009	August	0.03
Upper Lochan nan Lagasdail, Harris	2011	September	0.22
Loch Ness, Invernessshire	2012	July	0.07
	2012	August	0.12
	2012	September	0.01
	2014	September	0.03
	2016	September	0.01
	2018	July	0.01
	2018	August	0.01
	2018	September	0.01
Carron Valley Reservoir, Stirlingshire	2013	July	<0.01
	2013	August	0.11
	2013	September	0.04
Loch Ken, Dumfries & Galloway	2015	July	1.89
	2015	August	3.79
	2015	September	0.05
	2017	August	<0.01
Loch Awe north basin, Argyll	2015	August	0.01
	2017	July	0.01
	2017	September	<0.01
	2023	July	<0.01
Loch Kinord, Aberdeenshire	2017	May	<0.01
	2017	August	<0.01
	2017	September	0.10
	2022	July	112.0
	2022	August	0.68
	2022	September	0.48
Loch Ard, Stirlingshire	2017	August	<0.01
	2017	September	0.07
Loch Midgale, Sutherland	2018	July	0.02
	2018	August	<0.01
	2018	September	<0.01
Loch Awe south basin, Argyll	2018	August	<0.01
	2018	September	0.01
Loch Moan, Dumfries & Galloway	2022	August	3.9
	2022	September	22.9
Loch Ochiltree, Dumfries & Galloway	2022	July	0.65
	2022	September	9.0
Loch Maberry, Dumfries & Galloway	2022	July	0.02
	2022	August	0.03
	2022	September	7.21
Loch Venachar, Stirlingshire	2023	August	0.05
Loch Tralaig, Argyll	2023	August	<0.01
Loch Merkland, Sutherland	2023	July	0.02
	2023	August	0.04
	2023	September	<0.01

Table 1. Scottish records of *Gonyostomum semen*. Biovolume = volume of cells in a unit amount of water.

It is therefore not clear if *G. semen* is increasing its habitat range and frequency due to climate change and changes in anthropogenic activities in the catchments, or whether the alga is rare or missed in analysis due to its change in morphology following preservation, making clear identification difficult.

I would like to thank the reviewer – Dr Camilla Hagman – for her comments.

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The arrival of the water ladybird *Anisosticta novemdecimpunctata* (Coleoptera: Coccinellidae) in the Greater Glasgow area, Scotland

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The Scottish distribution of the water ladybird, *Anisosticta novemdecimpunctata* (Linnaeus, 1758), is limited to the southern part of Dumfries and Galloway, according to reference books published in recent years (for example: Duff, 2016; Roy, 2018). The National Biodiversity Network (NBN) Atlas at the time of writing tells the same story (NBN, 2023a). Recently, however, it has been observed at several locations in the Greater Glasgow area, so it seems appropriate to note this change as an example of the northward expansion of a number of insect species, perhaps due to climate change. The water ladybird, as its name suggests, lives in tall waterside vegetation in wet habitats, such as fens and marshes, where it feeds on aphids, and overwinters in grass tussocks and leaf sheaths (Duff, 2016). It is relatively small (*ca.* 4 mm in length), buff or red in colour with 14-19 black spots on the elytra, and six on the pronotum; it is more elongated and flattened than most ladybirds (Fig. 1).

Fig. 1. Water ladybird (*Anisosticta novemdecimpunctata*), Auchinlea Park, Glasgow, Scotland, 9th June 2023. (Photo: N. Digruber)

The water ladybird was first observed in the Greater Glasgow area at RSPB Baron's Haugh Reserve in September 2020 by Davie Abraham on reedmace ("bulrush", *Typha latifolia*) between the "Causeway" & "Phoenix" hides. This was a single individual. There have been sightings by the same observer on the Reserve in each subsequent year to 2023, including one record of *ca.* 12 individuals in 2021. And in May 2022, Davie Abraham reported another two individuals on emergent vegetation in the large pond beside the M74 service area at Hamilton Low Parks Local Nature Reserve (LNR).

It was first observed in Glasgow in May 2023 by Nicole Digruber at Auchinlea Park in the Easterhouse area (Fig. 1). In September, I myself swept one from emergent vegetation, mainly reed canary-grass (*Phalaris arundinacea*), in the recently constructed Sustainable Drainage System (SuDS) pond at Hamiltonhill Claypits LNR.

It is highly possible that the northward spread of this species is due to the effects of climate change, in particular the increase in average monthly temperatures. The limiting factor is presumably the temperature in the hills between the Solway lowlands and the central Scottish lowlands. It would be interesting to look for this species in other suitable waterbodies such as at Lanark Loch and the pools alongside the Douglas Water, both South Lanarkshire, particularly those at Douglas Castle Estate, and further downstream at Douglas Water village, which are likely to have suitable "fenny" margins. Now, of course, we should also look out for it in the northern part of the Glasgow conurbation, particularly at Possil Loch Scottish Wildlife Trust (SWT) Reserve, and at Bardowie Loch, Kilmardinny Loch LNR in Bearsden, both East Dunbartonshire, and perhaps even as far north as Loch Ardinning SWT Reserve near Strathblane, Stirlingshire.

However, the relationship between ladybirds and temperature is complex. For example, in species such as the water ladybird, which undergo a winter diapause (hibernation), warm spells during the winter can rouse the insects into activity at a time when food is scarce, resulting in them using up stored energy resources, and increasing the risk of winter mortality (Roy, 2013).

The general status of the water ladybird in Britain is that it is "declining" (Duff, 2016; Roy, 2018), so it is encouraging to see it apparently flourishing in new locations in this area.

The records mentioned have been submitted to the NBN and now appear in the NBN Atlas (NBN, 2023b), which also corrects an erroneous record at Balloch Castle Country Park.

I am grateful to Davie Abraham for first alerting me to the presence of this species in the Glasgow area and then keeping me updated, and to Nicole Digruber for details of her Glasgow observation.

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Four-spined legionnaires *Chorisops* spp. (Diptera: Stratiomyidae) in Glasgow and the west of Scotland

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The bright four-spined legionnaire *Chorisops nagatomii* Rozkošný, 1979 and the dull four-spined legionnaire *C. tibialis* (Meigen, 1820) are European species of soldierfly. *C. nagatomii* is a relatively recently described species, previously "lumped" with *C. tibialis*. Both species are about 6 mm in length and have a shining green thorax and a scutellum with four spines which are almost lacking in hairs. They differ in that *C. nagatomii* is described as having a shining green frons, bright orange posterior calli, and the dorsal surface of the abdomen is predominantly orange, whereas *C. tibialis* has a black frons, drab posterior calli, and the abdomen is much duller in colour, any orange being much less extensive (Stubbs, 2014) (Figs. 1 and 2A). Fig. 2B shows the foreparts of *C. tibialis* illustrating the dull frons and posterior calli, and the corresponding brighter areas of *C. nagatomii* are evident in Fig. 1. It should be noted that Figs. 1 and 2 show females. The males are darker and Speight (1981) mentions that the differences in colour of the frons and calli are variable and hard to distinguish, at least in some cases (M. Harvey, pers. comm.).

The larvae are associated with wood debris, rotten wood, rotting trees and leaf litter.

Fig. 1. Bright four-spined legionnaire (*Chorisops nagatomii*), female, Dorset, England 2014; length *ca.* 6 mm. (Photo: Malcolm Storey)

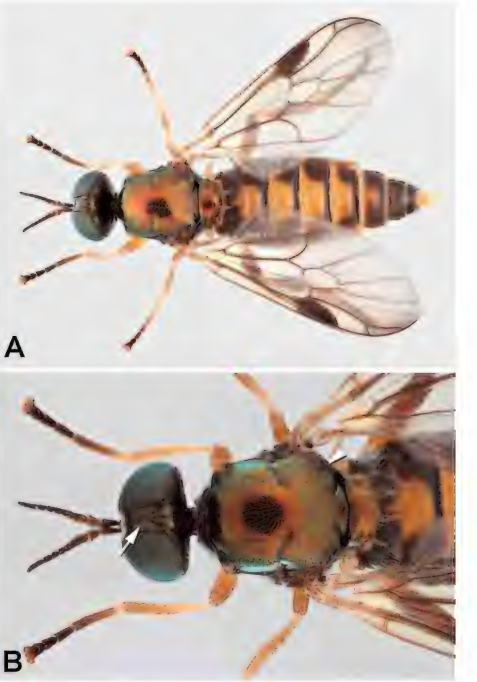

Fig. 2. Dull four-spined legionnaire (*Chorisops tibialis*), female, Dorset, England 2016. (A) Whole individual; length *ca.* 6 mm. (B) More magnified view of foreparts, showing dull frons (arrow) and posterior calli (arrowhead). (Photos: Malcolm Storey)

The National Biodiversity (NBN) Atlas shows only six Scottish records of *C. nagatomii*, all in the east (NBN, 2023a), four of which are in Edinburgh, and one in Dalgety Bay (Fife) and Kelso (Scottish Borders). This is perhaps not surprising in view of the relatively recent split from *C. tibialis*, the small size of the insect, and the relatively low level of recording of this species group. It would be expected that most *Chorisops* spp. observations would therefore have been recorded as *C. tibialis*, although there are only three Scottish records of that species (NBN, 2023b) from Kippford (Dumfries & Galloway), Motherwell (North Lanarkshire) and Cambuslang (South Lanarkshire).

The first Scottish record of *C. nagatomii* was by Graham Rotheray at Mote of Mark, Rockcliffe, Dumfries and Galloway in 2009. The earliest record in Glasgow Museums Biological Records Centre (GMBRC) database is from a moth trap beside the Forth and Clyde Canal at Old Kilpatrick, West Dunbartonshire in 2018. The other six records in that database are all 2023 sightings in Glasgow. The first Glasgow record was on 13th August 2023: I swept one from amongst shrubbery below trees in Glasgow Botanic Gardens, near the Great Western Road railings. I subsequently found four more

between then and the end of August, in the West End of Glasgow: two locations in Lancaster Terrace, and two locations in Hyndland Old Station Park; all the latter were swept from the lower tree canopy. Also within that period, another observer collected one in Glasgow Necropolis. By contrast, I have only found two records of *C. tibialis,* both from moth traps: at Hamiltonhill Claypits in July 2019, and at the Botanic Gardens in August 2020.

The National Museum of Scotland (NMS) holds no Scottish specimens of either *Chorisops* species, except the 2017 sighting of *C. nagatomii* in Dalgety Bay, thought at the time to be the first Scottish record. The Scottish Insect Records Index (SIRI) lists no records of either (V. Blagoderov, pers. comm.).

Stubbs & Drake (2014) describe the distribution of both as widespread in the south of England and Wales, though extending as far north as Cumbria; *C. nagatomii* is the rarer of the two species, and in some districts prefers the peat soils of fens; *C. tibialis* is reported as preferring shady places, unlike most soldier flies which prefer sunny positions (Stubbs, 2014). By contrast, all my specimens of *C. nagatomii,* were found in more or less shady places, away from fenny habitats; my *C. tibialis* specimens were from light traps, so cannot be compared directly.

In view of the apparent rarity and small size of *Chorisops* spp., it is difficult to draw any conclusions from these sightings, such as the rate and extent of the apparent spread and whether this may be due to climate change; the sightings in the West End of Glasgow are sufficiently close together to constitute one population. However, since there is an apparent rarity of recorders sampling suitable habits, it is reasonable to assume that it is probably under-recorded, though the lack of any older museum specimens or literature records seems to support the idea that they have arrived recently (M. Harvey, pers. comm.).

The Old Kilpatrick specimen and two of the Glasgow specimens of *C. nagatomii* have been deposited with the Hunterian Museum collections in Glasgow. The records described here will be submitted to the NBN Atlas in due course, along with records of other Stratiomyidae.

I am grateful to Geoff Hancock for confirming the identity of two of my Glasgow specimens of *C. nagatomii* and for suggesting that this account should also cover *C. tibialis*, to Vladimir Blagoderov for checking the NMS collections and SIRI, to Robyn Haggard for checking the Glasgow Museums collections, and to Malcolm Storey for permission to use his photographs.

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Leatherback turtle sightings in the Clyde Sea Area, Scotland in 2022

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The leatherback sea turtle (*Dermochelys coriacea*) is by far the largest turtle species, with adults typically from 1.8-2.9 m in length and weighing between 250-700 kg. They are also unique among sea turtles for having a leathery rather than bony shell. They are widely distributed in the world's oceans with the Atlantic population being found regularly as far south as the Cape of Good Hope, South Africa and as far north as Newfoundland, Canada. Breeding is, however, restricted to shores in tropical seas. They are capable of diving for up to 1.5 h and as deep as 1.2 km.

Leatherback sea turtles are able to generate and retain heat from the activity of their muscles, allowing them to have a body temperature above that of the surrounding water, which enables them to tolerate colder deep waters and to travel into cooler northerly waters (Lovich & Gibbons, 2021). In summer months they visit the west coasts of Britain and Ireland in search of their jellyfish prey and their wanderings may bring them further north to Norway and even north of the Arctic circle (Willgohs, 1957).

The occurrence of marine turtles in Scottish waters was reviewed by McInerny & Minting (2016). There were 350 records then known of turtles in Scottish waters: 250 leatherbacks, 50 loggerheads (*Caretta caretta*), nine Kemp's ridley (*Lepidochelys kempii*), four green turtles (*Chelonia mydas*), and about 80 turtles unassigned to species. Only adult leatherbacks (length 1.8–2.9 m) appear to visit Scottish waters. Most leatherback sightings are between June and October and are live animals, although some die following entanglement in fishing gear. Sightings or strandings of leatherback turtles in Scottish waters have often been newsworthy (Sutcliffe, 1981, 1983; Simpson, 1984). Even before the days of the internet and social media, the landing of a large leatherback could draw numerous sightseers, as was the case for one brought ashore at Ness, in the Western Isles, in 1987 (Anon., 1988).

As a regular visitor to Scottish waters, the leatherback turtle should be regarded as a *bona fide* member of our marine fauna. Leatherbacks arriving in Scottish or Irish waters may be accompanied by exotic fish, such as pilot fish (*Naucrates ductor*) or remora fish (*Echeneis naucrates*) and may also host unusual species of barnacles or crabs (O'Reilly *et al*., 2022).

The largest leatherback so far recorded in the U.K. was found stranded on Harlech beach, Wales, in 1988. It measured almost 3 m and weighed 914 kg and is now displayed at the National Museum of Wales (Hanley *et al*., 2013). It is perhaps understandable that some previous turtle sightings of leatherbacks in Scottish waters and elsewhere have been mistaken for mythical beasts (Brongersma, 1968a-c).

A database of all turtles ever recorded from the U.K. and Eire was established by Pierpont & Penrose (2002) and information on turtle strandings and live sightings since 2001 has been collated in annual reports produced by Marine Environmental Monitoring (MEM) (www.strandings.com). A long-term analysis of the occurrences of marine turtles around the coasts of Britain and Ireland was provided by Botterell *et al*. (2020).

A total of 286 leatherbacks has now been recorded all around the coasts of Scotland, though they appear to be more frequent on the western coasts (NBN, 2022). Details of some early records from the Clyde Sea Area were given by Sutcliffe (1981) and Gibson (1990), including the famous leatherback captured in Kilbrannan Sound in 1959 and transported to Calderpark Zoo, Glasgow. There are now about 20 records of leatherbacks in the Clyde Sea Area (NBN, 2022), including several records from Loch Fyne and, in 1989, one sighting in Loch Goil, a side-arm of Loch Long.

The first report of a leatherback turtle in the Clyde Sea Area in 2022 was on 17th July at Cairndow, near the head of Loch Fyne (NN1846911440). Just a few days later on 21st July, a leatherback was spotted again near Cairndow but just a little further south (NN1807911235). Just over a week later on 29th July, a leatherback was spotted at the head of Loch Striven (NS0536183674) by angler Mike Lindop. The turtle was not more than 20 m offshore and appeared to be feeding on jellyfish. A couple of photographs were taken (Figs. 1 and 2).

The first observation of a leatherback in Loch Long in 2022 was on the 8th September by Hazel McDonald who observed the turtle from a boat near Morelaggan (NN2752301883) about 2.5 km south-west from Arrochar. The turtle came up to breathe for about 10-15 s then dived. It was quite loud and when it put its head down three distinct ridges could be seen on its back.

On the 11th September, the Long Long Jetty Association (LLJA) posted a video clip of a large marine turtle seen that morning at the jetty in Arrochar

Fig. 1. Leatherback turtle (*Dermochelys coriacea*) in Loch Striven, Scotland, July 2022. (Photo: Mike Lindop)

Fig. 2. Leatherback turtle (*Dermochelys coriacea*) in Loch Striven, Scotland, July 2022. (Photo: Mike Lindop)

(NN29450362) (for link to the video, see LLJA (2022)). The sea state was flat and calm and the video shows the turtle swimming toward the viewer just beneath the water surface before turning shore-wards in a half circle and heading off parallel to the shore in a southerly direction. At closest approach the turtle was only about 5-6 m away and the proximity of the rocks and seaweed on the shore allows the viewer to gauge its length as about 2 m confirming, based on this large size, that it was a leatherback.

On the afternoon of the same day the turtle was also seen nearby by Calum McIlwraith who was fishing with friends from the rocks at the Loch Long caves (NN2784902073), just over 2 km south-west from Arrochar. He provided this account: "The loch was very flat and calm and it was very overcast and raining fairly heavily. The turtle surfaced about ten feet away from us when the tide was still relatively high around 3:30 p.m. Initially we thought it was the seal that chases our mackerel although we got such a fright when we realised it was easily double the size of a seal and had a ridged back. It then pushed back into the water with flippers that must have been 3 ft. each and disappeared for around 5-10 minutes. It then resurfaced further out on the loch and I managed to get a video clip although you can only just make out its head. The turtle just seemed to be swimming and breaching whilst taking breaths". The video can be viewed at https://www.youtube.com/shorts/1HA4vPi6bac.

As news of the turtle sightings spread on social media a further posting suggested that an angler had inadvertently snagged a hook on the turtle and the British Divers Marine Life Rescue (BDMLR) organisation were alerted. The story of the initial turtle sighting and the video clip from the Arrochar jetty appeared in the press a few days later (Anon., 2022a,b; Fitzpatrick, 2022 (which includes a link to the original video)). There were further sightings at Arrochar, reported to BDMLR, on 17th and 18th September. With the turtle so far up at the head of the loch, there was some concern it may become trapped there, as had three bottlenose whales (*Hyperoodon ampullatus*) near Garelochhead in 2020 (O'Reilly & Payne, 2021). However, there still appeared to be many jellyfish at Arrochar for the turtle to fed on and there was no indication that it was injured or was in any difficulty. Sightings continued around Arrochar over the next few days.

On 27th September, at around 12.40 p.m., James Gilchrist was recovering a boat across the loch at Ardgartan (NN2768102985) when he spotted the turtle about 100 m offshore. The weather was slightly overcast with a light breeze and so the sea state was calm. A video clip was taken, on a phone camera, looking north from Ardgartan before swinging round looking directly east across the loch. However, the turtle is clearly seen for only around 10 s bobbing on the surface. The head and back were visible and it seemed to be mouthing at something. The video clip can be viewed at https://youtu.be/XuzrKQAMsGs.

On the same date, while paddle boarding south west of Arrochar, Gemma Varley, a BDMLR volunteer, sighted the leatherback at 5.30 p.m. approximately 250 m north of Ardmay House Outdoor Centre (NN2826302779); the sighting lasted for approximately 25 min. The turtle was observed travelling east and west across the loch before heading south. The head and back clearly visible, it was observed diving and resurfacing several times.

There were several more sightings reported in the Arrochar area around 28th September and an image was captured by David Devoy, a BDMLR volunteer and keen paddle boarder. The photo from the shore is looking south-west towards the promontory at Ardmay House (NN28250280). The image clearly shows the turtle's head and ridged back (Fig. 3).

There was a further sighting by local fishermen on September 29th. On the morning of 30th September BDMLR dispatched three volunteers in response to a call from the Scottish Society for Prevention of Cruelty to Animals (SSPCA) which had received a report from

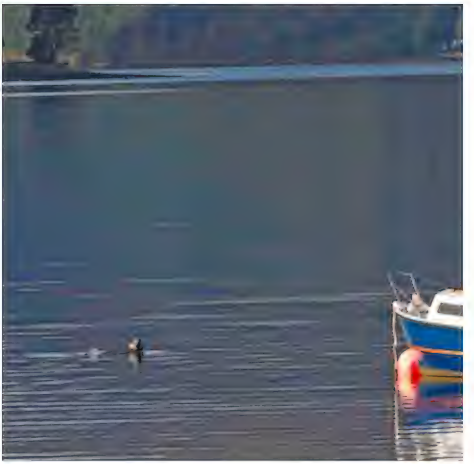

Fig. 3. Leatherback turtle (*Dermochelys coriacea*) near Ardmay House, Loch Long, Scotland, September 2022. (Photo: David Devoy)

a member of the public of a leatherback in distress in shallow waters below Ben Arthur Bothy in Arrochar (NN2982304482). A search in the reported locality within an hour of the call was followed by a more extensive evening walk of the shore and by paddle board which both revealed nothing. However, later discussions with some local fishermen and tourists established that the leatherback had been seen free swimming near Arrochar mid to late afternoon showing no signs of distress.

The next sighting in the area was on 10th October at Arrochar. There were no subsequent reports of turtles, either alive or dead, within Loch Long or the Clyde Sea Area in 2022. It is therefore assumed that the turtle safely left the area.

The most recent previous sighting of a leatherback in the Clyde Sea Area was at Loch Gilp in August 2006. The 2022 leatherback sightings described here are the first from Loch Striven and Loch Long. With leatherback sightings in 2022 in three different Clyde sea-lochs, it is unclear whether only one, or more than one, turtle was being observed. It is quite probable that the records in Loch Fyne and in Loch Striven around a week later are the same turtle and it is even plausible that the sightings just over a month later in Loch Long may also be the same individual. Although leatherbacks have unique skin mottling patterns which might allow individuals to be recognised, it is very difficult to photograph these in the field unless the turtles are captured.

The prevalence of social media has helped alert anglers, recreational water-users and other sea-farers to turtles visiting our shores and it is hoped that others will be lucky enough to catch a glimpse of these fascinating creatures.

Thanks are due to Mike Lindop, Hazel McDonald, Calum McIlwraith, James Gilchrist, Gemma Varley and David Devoy for relating first-hand accounts and images of the leatherback in Loch Striven and Loch Long. Rod Penrose (Marine Environmental Monitoring, Cardigan) provided an up-to-date export from the turtle record database for the U.K. and Eire.

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The Glasgow Natural History Society Scottish Herpetological Conference, June 2023: origins, organisation, experience and proceedings

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INTRODUCTION

In June 2018, the Glasgow Natural History Society (GNHS) organised a conference as part of the Glasgow Science Festival entitled *The Amphibians and Reptiles of Scotland: Current Research and Future Challenges*, whose proceedings were published in a supplement issue of Volume 27 of *The Glasgow Naturalist* (https://www.biodiversitylibrary.org/item/274374).

The 2018 conference was the third herpetological conference to be held in Scotland, with the previous two being in Glasgow during November 2011, and Edinburgh during October 2014, both part of the series of Herpetofauna Workers meetings which occurred annually at various venues across the country.

The 2018 conference was prompted by the publication in 2016 of *The Amphibians and Reptiles of Scotland* (McInerny & Minting, 2016) by the GNHS, which had stimulated much discussion about areas of Scottish herpetological interest that needed further study and research. By 2023 it was thought that the time was right to revisit the status of herpetological study in Scotland, and the idea of a follow-up conference was proposed to the GNHS Council, who supported the proposal.

A committee comprising the authors along with Ehm Downie, Deborah McNeill and Erik Paterson then put the idea into action. The committee meetings proceeded via Zoom, with correspondence through e-mail; JRD chaired and minuted the meetings.

The committee first agreed that the conference would be a contribution to the 2023 Glasgow Science Festival, identifying the date as Saturday 3rd June. This also allowed conference rooms and space within the University of Glasgow's new and well-equipped Advanced Research Centre (ARC) to be used (Figs. 1 and 2). The committee realised that making the conference a "hybrid", delivered in-person but also with online Zoom attendance an option, would maximise attendance, and the technical support offered by the ARC made this feasible.

JRD wrote and submitted a funding application to GNHS's Blodwen Lloyd Binns Bequest (BLB) grants committee who awarded the conference up to £1,000 to cover speaker expenses, refreshments (so that these could be free to all attendees), speakers' lunches and Glasgow Science Festival registration. JRD also obtained donations from the British Herpetological Society, Froglife, Amphibian and Reptile Conservation, Amphibian and Reptile Groups UK, and the Friends of Angus Herpetofauna to support conference expenses. As the conference was a contribution to the Glasgow Science Festival there was no room hire charge or janitorial costs.

Fig. 1. The Scottish Herpetological conference welcome and introduction. (Photo: Andy Wilson)

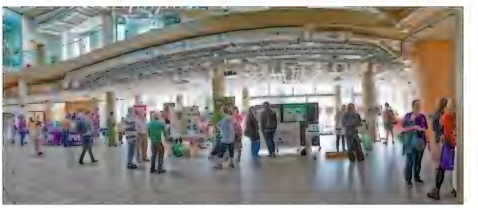

Fig. 2. The Scottish Herpetological conference atrium with stands and posters in the ARC, University of Glasgow. (Photo: Andy Wilson)

Gathering a set of high-quality speakers was the responsibility of JRD, along with inviting the contribution of stands by the sponsoring organisations (Fig. 2). ND managed and supported the submission of poster presentations, short talks, and advertising

material for the conference. Although the focus of the conference was on herpetology in Scotland, a few presentations of broader relevance were included, especially if they contained useful lessons for Scotland, such as the work on the impacts of Eurasian beavers (*Castor fiber*). The organising committee also felt that it would be useful to include herpetological topics for discussion, to give attendees an opportunity to air their views on relevant current issues: JRD wrote introductory texts for two alternative topics: (1) Should the international trade in wild-caught amphibians and reptiles be banned? and (2) The threats facing Scotland's herpetofauna, and what can be done about them. JRD also liaised with the ARC and the Glasgow Science Festival, whose EventBrite booking system was used to register members of the public wishing to attend the conference.

Thirteen speakers agreed to give standard length (20 minutes) talks on the day and four to give short (5 minutes) presentations. Angela Julian gave her talk remotely live through Zoom while Daniele Muir and Jenny Tse-Leon provided pre-recorded talks which were projected on screens. Unfortunately, neither Chris Cathrine nor Colin Dunlop was able to give a talk on the day, although the former was later able to provide a paper based on what he had hoped to talk about, and this has been included in the Proceedings. Most speakers provided talk titles and abstracts in advance for the printed conference programme. The short presentations were supported by posters in the ARC atrium (Fig. 2). The atrium was also the location for stalls brought by five organisations. Over 80 people signed up to attend in person: many on the EventBrite list could not make it, but others did, resulting in a total of 81 attendees on the day. A further eight signed up for attendance online, though the remote link did not work well.

Scottish Environment Link organises a Nature Champions scheme which invites Members of the Scottish Parliament to act as champions for particular species or habitats. At the time of organising the conference, most Scottish species of amphibians and reptiles, and one relevant habitat had champions (Table 1). JRD wrote to the champions inviting them to participate in the conference in some way, by sending messages of support or attending and speaking. The response was limited and disappointing, but some did send messages and Brian Whittle agreed to attend and give a short presentation.

Several members of GNHS and two University of Glasgow students volunteered to staff the registration desk and the refreshments stall. Andy Wilson (GNHS photography convenor) generously agreed to take photographs of the event (Figs. 1 and 2). Twenty three attendees completed Festival feedback forms, with 70% rating the event as excellent, and 30% as very good.

CJM and ND chaired the morning and afternoon sessions of the conference, with CJM providing a welcome and introduction and JRD the closing remarks. CJM and JRD led the afternoon discussion sessions, with Martha Stone-Shepherd and Ehm Downie acting as scribes.

Regarding the assembly of the conference proceedings published in this issue of *The Glasgow Naturalist*, not all speakers were able to provide written-up versions of their talks, usually because the work reported on was at too early a stage, or because it was scheduled for publication elsewhere. Where this is the case, we provide below only the abstract (or an extended version of the abstract) that was included in the printed conference programme.

The providers of posters at the conference were also encouraged to develop their presentations into Short Note format papers to be published as part of the proceedings, and these, where completed, have become valuable permanent accounts. JRD, ND and CJM have acted as referees for all these papers and shorter contributions, with additional oversight by the Editor.

Species/Habitat	**MSP**
Adder (*Vipera berus*)	Martin Whitfield
Common lizard (*Zootoca vivipara*)	-
Slow worm (*Anguis fragilis*)	Daniel Johnson
Leatherback turtle (*Dermochelys coriacea*)	Brian Whittle
Common frog (*Rana temporaria*)	Shirley-Anne Somerville
Common toad (*Bufo bufo*)	-
Natterjack toad (*Epidalea calamita*)	Fulton McGregor
Great crested newt (*Triturus cristatus*)	Emma Harper
Smooth newt (*Lissotriton vulgaris*)	Jenny Gilruth
Palmate newt (*Lissotriton helveticus*)	Murdo Fraser
Ponds, small lochs	Emma Harper

Table 1. Scottish Environment Link Nature Champions (herpetofauna), 2023.

PROGRAMME

Talks:

10.00 Chris McInerny: Welcome and introduction (Fig. 1).

Chair: Chris McInerny

10.05 Brian Whittle MSP: Scottish Environment Link's Nature Champions scheme for the leatherback turtle.

Summary

Brian began by explaining what had stimulated his interest in marine turtles: the experience of sub-aqua diving in the Red Sea where he swam close to green and loggerhead turtles. He then summarised the threats that marine turtles face worldwide: by-catch in the longline fishing industry, global warming's effects on the sex ratio of hatchling turtles (due to their temperature-dependent sex determination system), plastic pollution in the seas, where turtles can mistake plastic bags for jellyfish prey, and touristic development of nesting beaches, making them unsuitable for turtles (a problem because most turtles species tend to show high natal beach fidelity, returning to nest at the beach where they hatched out). As well as being nature champion for the leatherback turtle, now recognised as a regular visitor to Scottish waters, Brian is Shadow Minister for the Environment, Biodiversity and Land Reform, and is keen to encourage better environmental protection in Scotland, on several fronts. He concluded by speaking briefly on the Nature Champions scheme (to which over 80 MSPs are signed up) (Table 1), and wishing success to the conference.

10.10 John Howieson (University of the West of Scotland): Citizen Science and eDNA for the targeted detection of amphibians in coastal environments.

Abstract

Amphibians are negatively affected by salt water, with effects ranging from mortality to developmental delays and abnormalities. With rising threats associated with climate change, such as increased incidences of extreme weather events and seawater inundation due to flooding, amphibians within coastal environments are at risk from freshwater salinisation. However, numerous reports of amphibians inhabiting brackish water suggest that some species may display an evolutionary resilience to saline conditions. The evolutionary mechanism of this resilience is largely unknown, with the nature of these molecular mechanisms (adaptive or plastic responses) being predominantly unexplored. Here, we sought to investigate the presence of U.K. amphibians (common toad, *Bufo bufo*; natterjack toad, *Epidalea calamita*; common frog, *Rana temporaria*; great crested newt, *Triturus cristatus*; palmate newt, *Lissotriton helveticus*; and the invasive alpine newt, *Ichthyosaura alpestris*) in saline sites using eDNA-targeted detection methods to identify which species are demonstrating salt resilience. Through the development of species-specific primers, we have established and optimised an eDNA assay for the detection of these species (alongside widely-established *T. cristatus* primers). Species distribution data from eDNA-targeted detection will be used alongside water quality parameters to infer which U.K. species are more frequently found in brackish environments.

10.30 Catherine Whatley (University of the West of Scotland): Development and validation of biomonitoring techniques for studies on pollution in wild common frogs (*Rana temporaria*).

Abstract

The aim of this DEFRA-funded Ph.D. project is to develop non-destructive biomonitoring techniques for endocrine-disrupting chemicals (EDC) in wild common frogs across the central belt of Scotland. The presentation gave an overview of the project and the different ways in which EDCs can be detected in the wild, and how their effects on common frog reproduction and development will be studied.

10.50 Fairlie Kirkpatrick Baird (NatureScot, Inverness): Drought in Scotland?! Combining models and field observation to predict impacts of drought on Scottish amphibians.

Abstract

Climate change is already leading to an increase in extreme events, including drought. Drought is projected to increase in both frequency and severity, even in temperate countries in Europe (Baird *et al.*, 2023). Amongst the animals most vulnerable to these changes are amphibians, as most species rely on water bodies for at least one life stage. Scotland provides an example of a country that is projected to experience substantial increases in drought in the near future, with likely impacts on its amphibian populations. While some species such as the natterjack toad (*Epidalea calamita*) are well adapted to summer drought and may benefit, the remainder of native species are likely to be negatively impacted. Using data on pond water levels and desiccation rate, we found evidence of drought during the breeding season (April to June) between 2014 and 2022. Our analyses combine drought models with field observations and suggest that drought is already a significant concern for amphibian conservation and resilience. Further, the changes are occurring sooner than expected, potentially turning otherwise healthy ponds, including those in nature reserves, into trap habitats for several species. Conservation initiatives, therefore, need to take drought increases into account when designing interventions.

11.15 Ehm Downie: Clyde Amphibian and Reptile Group's Greater Glasgow pond surveys, 2022.

11.35 Daniele Muir: Tayside Ponds Project.

Abstract

The aims of the project are to deliver positive effects for biodiversity and enhance local ecosystems, to promote the health and well-being of local communities, and to reduce inequalities. This is very much a partnership project, led by the Tayside Biodiversity Partnership together with the Tayside Amphibian & Reptile Group, and working directly with Perth & Kinross Council, the British Dragonfly Society and Amphibian & Reptile Conservation. Funding has been kindly provided by the

Scottish Government's Nature Restoration Fund allocation to local authorities.

Phase 1 (Winter 2021/22) – the project improved ponds for wildlife and provided volunteering opportunities at six ponds, several of them SuDS ponds (Sustainable urban Drainage Systems) namely the Elm Drive SuDS, Blairgowrie; Craighall SuDS, Rattray; Davie Park Pond, Rattray; Murthly SuDS pond; Scone Park Pond; and the Norrie Miller Pond, Perth.

Phase 2 (Winter 2022/23) – we returned to some of the ponds partly improved in phase 1 and also worked with volunteers at Aberdalgie, the North Inch SuDS pond, Perth and the Guildtown SuDS pond. As well as improving the habitat for amphibians and other watery wildlife, we planted native wildflowers for pollinators. The final phase of the project (Winter 2023/24) will see us again returning to some of the larger ponds which still need help (including the North Inch SuDS, Murthly; Elm Drive SuDS, Blairgowrie). We will also be working with local volunteers at both the Abernethy and Barratts Huntingtower housing developments, together with the SuDS at the West Park development in Blairgowrie.

In 2023, we had a few new groups of volunteers helping out including a John Muir Award group from Perth Academy & Perth and Kinross Council's Biodiversity Ambassadors. We also had some corporate volunteers in the shape of Studio Alba Architects, who funded some amphibian ladders to go into gullypots close by. We look forward to welcoming more volunteers at ponds for puddocks this year!

Chair: Nicole Digruber

13.20 Jenny Tse-Leon: Protecting Britain's wildlife laws.

13.40 Angela Julian: The Scottish national adder survey (SNAS) 2022-24.

14.00 Kathy Wormald: Froglife's Come Forth for Wildlife project.

14.20 Myles O'Reilly (SEPA): Marine turtles as vectors of exotic fauna to Scottish waters.

Abstract

The history and occurrence of marine turtles in Scottish waters is briefly reviewed. Some recent cases of loggerhead turtles stranded with numerous goose barnacles are discussed and compared with a stranding of a leatherback turtle with embedded acorn barnacles. The ecologies of goose barnacles (*Lepas anatifera*) and heloniphilic acorn barnacles (*Stomatolepas dermochelys*) are compared, including their attachment modes and how turtles rid themselves of barnacles. The occurrence of turtle debilitation syndrome is outlined. Records of exotic turtle barnacle species in Scottish and nearby waters are summarised and other exotic faunal species which accompany turtles are discussed. Much of this work has been published in O'Reilly *et al.* (2022).

14.40 Jude Wilson: The short-term impact of Eurasian beavers (*Castor fiber*) post reintroduction on amphibian abundance and diversity in a lentic environment.

15.00 John Smout (University of Glasgow): The molecular evolution of viviparity: analysing selection across the squamate family tree.

Abstract

The evolution of viviparity (live birth) from oviparity (egg-laying) has occurred more frequently in the Squamata than in any other vertebrate group: over 100 times. However, the genetic basis of viviparity in the squamates and other vertebrates, and the extent to which the evolution of viviparity is driven by convergent or parallel evolution at the genomic level is poorly understood. Natural selection drives the evolution of traits associated with viviparity and signals of these selective pressures are detectable at the genomic level. Here, I present preliminary results from our analysis of signals of selection in the molecular evolution of the Squamates. I include over 100 squamate species, harnessing the increasing availability of whole genomic sequence data for a wide range of squamate taxa. This analysis will reveal which genes change consistently across multiple squamate groups during the evolution of viviparity.

15.40 Short Talks and Posters:

Liam Templeton: Species on the Edge - coastal treasures of the eastern Solway.

Janet Ullman: Champhibians - a Scottish pond adoption scheme for schools.

Alexia Hesten (Liverpool John Moores University): Wildlife trade of reptiles and amphibians.

Abstract

The talk described the trade of reptiles and amphibians in the U.K. including investigating the risks of disease spill-over to native wildlife through swabbing of animals, and the use of questionnaires and interviews aimed at key stakeholders in the trade. In addition it outlined how the trade in herpetofauna has changed over time, in terms of supply chain, structure and sustainability, by analysing import data from the CITES database and other sources. Through this approach, it is hoped to shed light on a large, but poorly understood industry, and help to better inform both policy-makers and stakeholders in the trade, with the aim of improving the trade in the long-term.

Lauren Jeffrey, Tom Major & Wolfgang Wuster (Bangor University, north Wales): Habitat selection during movement pathways in the Aesculapian snake (*Zamenis longissimus*) in North Wales.

Abstract

The Aesculapian snake (*Zamenis longissimus*) is a widespread European species with two introduced populations in Regents Canal, London, and Colwyn Bay, North Wales in the U.K. The population in North Wales was introduced in the 1970s and is the northernmost extant population. Despite being present in the area for over 50 years, we still know very little

about their ecology due to their secretive behaviour. Snakes can also exhibit a high degree of individual heterogeneity in behaviour which complicates predicting their movements. The aim of this study was to investigate the movement ecology of the Aesculapian snake in their introduced range in North Wales to identify possible dispersal routes and constraints. Firstly, we wanted to identify which habitat features were selected along movement pathways. Secondly, we aimed to determine if snakes had a preference for anthropogenic features and hedgerows. Lastly, we set out to establish if roads act as a possible dispersal barrier constraining their ability for range expansion. We radio-tracked a total of seven adult male Aesculapian snakes five times daily between May and August 2022 using VHF telemetry and transmitters that were surgically implanted under anaesthesia. We used Integrated Step Selection Functions (ISSF) to estimate the relationship between movement and habitat selection by comparing used against available locations. Our findings showed snakes to have high individual heterogeneity. At the population level, Aesculapian snakes were positively associated with hedgerows, buildings, and scrub. Continued research and monitoring are needed to fully understand the capabilities, potential impacts, and to respond rapidly to any future changes.

16.15 Discussion Sessions:
Roger Downie (Lead): Topic 1: Should the international trade in wild-caught amphibians and reptiles be abolished?

Chris McInerny (Lead): Topic 2: The threats facing Scotland's herpetofauna, and what can be done about them.

17.00 Martha Stone-Shepherd and Ehm Downie: Report on Discussion sessions.

17.15 Roger Downie: Closing remarks.

Posters
Species on the Edge; Champhibians; Wildlife trade of amphibians and reptiles; Movement ecology of non-native Aesculapian snakes in north Wales (Fig. 2).

Stands
Froglife; Glasgow Natural History Society; Clyde Amphibian and Reptile Group; Amphibian and Reptile Conservation; British Herpetological Society; Friends of Angus Herpetofauna (Fig. 2).

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We wish to thank all the speakers and poster providers for their presentations on the day and particularly those who wrote them up as a permanent record; also all helpers on the registration desk and refreshments table; the BLB grants committee, the British Herpetological Society, Froglife, Amphibian and Reptile Conservation, Amphibian and Reptile Groups UK, and the Friends of Angus Herpetofauna for providing funding to support the conference and for providing stands; Deborah McNeill for Glasgow Science Festival interactions, and ARC staff for assistance on the day.

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The *Come Forth for Wildlife* and *Fife Living Water* projects

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ABSTRACT

Froglife is a national wildlife conservation charity that has been active in Scotland since 2008. This article describes the activities involved in two recent projects carried out in different areas of Scotland - the Forth Valley and Fife. Froglife's work combines active practical conservation (these projects created 205 ponds, restored 22, and improved 370 terrestrial habitats) with public engagement (over 200,000 people in these projects) and opportunities for both paid and volunteer training.

INTRODUCTION

The Froglife Trust (Froglife) is a national wildlife conservation charity with a remit to conserve the U.K.'s native reptiles and amphibians. Froglife is a practical organisation that works on the ground, restoring and creating habitats for the species that they represent. However, this work also benefits a wide range of other species, including birds, small mammals, aquatic plants, and invertebrates. Central to Froglife's ethos is the aim to assist as many people as possible, particularly those that are currently under-represented in the wildlife conservation sector, to be able to take action to help the U.K.'s native wildlife, whilst also drawing on the many benefits that engaging with nature gives people.

Since 2008 Froglife has delivered several large, impactful projects transforming landscapes across Scotland. Of these, Larcombe & Stead (2018) reported on the outcomes of the 4.5-year Scotland-wide *Dragon Finder* project. The *Come Forth for Wildlife* (2019-2023) and *Fife Living Water* (2022-2023) projects were Froglife's most recent large-scale works in Scotland. *Come Forth* operated in the Forth Valley and, in addition to large-scale habitat creation and restoration, a major component of the project was the delivery of public engagement activities. *Fife Living Water* delivered large-scale habitat works at a wetland site in Cowdenbeath, Fife, and connected this site with another in Cowdenbeath, the Swan Pond. *Fife Living Water* also delivered sessions with local schools and volunteer sessions with local businesses. The Froglife team in Scotland continued to deliver habitat work throughout the COVID-19 pandemic, but public engagement sessions had to be paused for a while. However, once lockdown was eased, we were able to resume public engagement sessions and even exceeded our targets in the end for both projects. This article details the outcomes and impacts that these projects had on habitats, species, and people.

The projects delivered habitat works, wildlife gardening workshops, pond doctor events, a mapestry (a mapestry combines the visual information of a map and qualities of the locality), virtual reality exhibitions, training courses, neighbourhood wildlife corridors and volunteer sessions. These two projects created 205 ponds, restored 22 ponds, and improved 370 terrestrial habitats. The projects engaged with over 200,000 people, over 29,000 helping with the creation of neighbourhood wildlife corridors (Table 1).

Activity	People	Sessions
Wildlife gardening workshop	825	60
Pop-up wildlife gardening workshops	1,635	12
Mapestry	813	25
Mapestry tour	154,984	13
Pond doctor and events	6,575	48
Virtual reality exhibitions	8,822	23
Training courses, community engagement, school and group sessions, business team-building days	657	42
Volunteer sessions	3,276	260
Neighbourhood wildlife corridors	29,009	0
Total	**206,596**	**483**

Table 1. The numbers of people involved across the two Scottish Froglife projects, *Come Forth for Wildlife* and *Fife Living Water*, and the numbers of sessions held.

PROJECT ACTIVITIES AND RESULTS

We delivered wildlife gardening workshops (Fig. 1), pop-up wildlife gardening workshops and pond doctor tents (Fig. 2). These all provided expert advice on pond creation, restoration, and management. The activities attended science festivals, country parks, allotments, community gardens, therapeutic gardening groups, and reached out to new audiences by attending the Highland Games, Comic-Con Scotland (annual celebration of comics, cartoons etc. held at the Royal Highland Centre, Ingliston, Edinburgh), community festivals and popping up at railway stations.

Fig. 1. Wildlife gardening workshops helping people to understand the difference between an ornamental garden and pond and a wildlife garden and pond. (Photos: Froglife)

Fig. 2. Pond doctor events held at various venues provided advice to the public on pond creation, restoration and management. (Photos: Froglife)

The projects engaged new audiences by delivering novel activities such as Virtual Reality (VR) experiences (Fig. 3), mapestry sessions (Fig. 4) and tour, and an augmented reality app with a wildlife pond visualiser and ideazone. The VR experience asked the question: "When will wildlife get the green light?", highlighting the issue of road mortality and campaigning for more wildlife crossings. Comments from the experience include "I never knew that toads needed help!"

The mapestry activity created a map tapestry of the local heritage of the Forth Valley. We worked with local groups, arts venues, schools, and outdoor venues. The completed mapestry, containing twelve sections to represent each month of the year, toured venues such as parish churches, schools, The Helix Visitor Centre

Fig. 3. Virtual Reality (VR) experience within a mock wildlife tunnel exhibit. (Photo: Froglife)

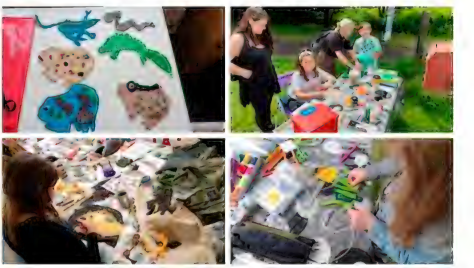

Fig. 4. Mapestry session: the final artwork was pieced together by a tapestry artist. (Photos: Froglife)

(Falkirk, Stirlingshire), shopping centres and community centres. It was viewed by over 200,000 people. Comments include "Looking good! Shows creativity and care for the environment". At the end of the tour, long-term homes were found for the mapestry panels.

We created and restored ponds and terrestrial habitats (Fig. 5). Terrestrial habitats are often overlooked but are crucial habitats for both amphibians and reptiles. Adult amphibians will spend more time in terrestrial habitats than in water, and hence require areas where they can forage, take refuge from predators, and hibernate over winter. Reptiles require areas for basking – sunny bare ground, and vegetated areas for hunting for food and to hibernate.

Neighbourhood wildlife corridors (Fig. 6) provided connectivity between the large-scale habitat creation and restoration works and urban neighbourhoods. These are smaller-scale interventions that create steppingstone habitats. Connectivity between habitats is crucial, particularly for amphibians and reptiles. Due to their ecological requirements, they are unable to travel great distances, and require mosaic habitats for different seasonal requirements.

Crucial to Froglife's work is that it leaves a legacy ensuring that all we have achieved is maintained on the ground. Froglife achieves this through an extensive volunteer training programme. They train volunteers in habitat creation, restoration, management, and species surveying. They provide ongoing support to volunteer groups through their commitment to revisit all habitat

Fig. 5. Kildean wetlands, Stirling. Before habitat creation: a non-biodiverse area of scrubby grassland; and after the creation of a potentially diverse pond habitat. (Photos: Froglife)

Fig. 6. Steppingstone habitats linking large-scale habitat works to urban areas. (Photos: Froglife)

sites where they have worked, 1-, 3-, 5- and 10-years post-works: this provides an opportunity to undertake habitat assessments and reconnect with volunteer groups.

In line with Froglife's mission to involve new audiences in wildlife conservation, they offer paid-for trainee positions (Fig. 7). An essential element of the training is to provide practical habitat creation and management experience and experience in engaging with the public, often elements that are missed in formal education. These projects provided positions for two trainees, both of whom went on to further employment within the conservation sector.

These projects created and restored vital freshwater and terrestrial habitats across the Forth Valley and into Fife, particularly for the benefit of our native reptile and amphibian species. However, they also provided

Fig. 7. Trainees experiencing the practical elements of nature conservation, including public engagement. (Photos: Froglife)

suitable habitats for a wide range of other wildlife. The projects engaged with over 200,000 people, mostly new audiences to nature conservation, encouraging these people to take further actions to help Scottish wildlife. Projects that combine habitat works with innovative and engaging public engagement activities have a huge impact on helping Scottish nature to recover and grow.

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An overview of the Scottish National Adder Survey 2022-24

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ABSTRACT

A study was commissioned by NatureScot to analyse changes in the status of the adder (*Vipera berus*) and other native reptiles at 16 sites across mainland Scotland, the Isle of Skye and the Isle of Arran over a 30-year period from 1992-93 to 2022-24. In 2022-24, volunteer surveyors revisited sites that were previously surveyed in 1992-93 to identify changes in occupancy. Visual surveys recorded adder, common lizard (*Zootoca vivipara*), slow-worm (*Anguis fragilis*), common frog (*Rana temporaria*), common toad (*Bufo bufo*), smooth newt (*Lissotriton vulgaris)*, and palmate newt (*Lissotriton helveticus*). Adders were observed in comparable or even greater numbers at eight sites (seven of the original sites surveyed in 1992-93), but an apparent loss of adders at three of the original sites, and major declines at a previously favourable site on the Scottish Borders are cause for concern. Of the other reptiles, common lizards were the most widespread, recorded at 12 sites; and slow-worms were least often recorded, in low numbers at only four sites, though this could be expected in visual surveys for this cryptic species. This publication reviews the factors most likely to be affecting adders in Scotland, particularly the loss of suitable habitat, the likely historic impact of persecution and the potential effects of disturbance by recreational site users. It highlights the importance of sympathetic habitat management, with a particular focus on maintaining favourable micro-habitats for reptiles.

INTRODUCTION

Across Britain, populations of the adder (*Vipera berus*) have declined dramatically since the mid part of the 20th century (Baker *et al*., 2004; Gardner *et al*., 2019), and the species is considered to be "Near Threatened" in Scotland and Wales and "Vulnerable" in England, in the most recent IUCN Red List assessment (Foster *et al*., 2021). Although adders are still reported to be widespread across mainland Scotland and some islands in the Inner Hebrides (Reading *et al*., 1996; McInerny, 2014a; McInerny & Minting, 2016), anecdotal reports suggest populations may have declined across the range.

In 1992, the then Scottish Natural Heritage (SNH) (now NatureScot) commissioned a survey to investigate the status and distribution of the adder in Scotland with Biosphere Consultancies and the Scottish Agricultural Service. In addition to an extensive farm questionnaire, visual surveys were conducted by volunteers at 17 sites across Scotland to develop a base-line for adder distribution and abundance. Each site was visited 2-12 times, amounting to a total of 97 visits (Reading *et al*., 1994, 1996).

The results of the farm questionnaire showed adders to be absent from a number of regions including the Central Valley, the Outer Hebrides and the Northern Isles, as well as much of the mountainous Central Highlands region between Inverness and Glasgow (Reading *et al*., 1994, 1996). The study demonstrated adder distribution to be strongly correlated with land use, being positively associated with heterogeneous areas and negatively associated with intensively arable and rocky/rugged mountainous areas. Finally, the study provided evidence that adder abundance had declined over the ten-year period prior to the 1990s (Reading *et al*., 1994, 1996).

The objective of the present study was to repeat the original survey and questionnaire after a period of 30 years during 2022-24, following the same methodologies, to gain an insight into the adder's current status and determine whether further changes in adder populations could be detected. This paper covers the findings of the first two years of the field surveys conducted by volunteers between 1st April 2022 and 31st March 2024.

MATERIALS AND METHODS

Site Selections

Communications with Dr Chris Reading (U.K. Centre for Ecology and Hydrology), principal investigator on the original 1992-93 survey, enabled us to identify and map the 17 original sites (Fig. 1). Much can change in 30 years, and in some cases it was difficult to accurately replicate the original transect routes. Nevertheless, with advice from the land managers, and the original reptile records, we were able to identify survey routes for 15 of the original sites. We also identified one additional site (12b), in Edinburgh and the Lothians.

Recruiting surveyors

Surveyors were initially recruited during a half-day workshop at the online Scottish ARGs Meeting on

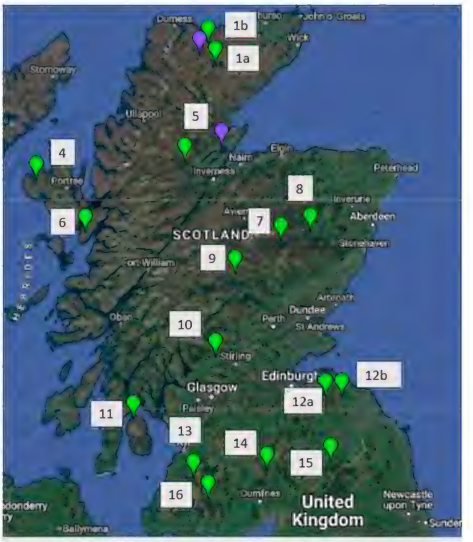

Fig. 1. Active Scottish National Adder Survey sites from 2022-23 (green markers) and from 1992-93 only (purple markers).

Saturday 30th October 2021. From this event, and subsequent appeals made through the partner organisations' networks and social media, we were able to recruit 102 potential volunteers for the survey. Each volunteer was provided with the *Scottish Adder Survey Protocol* which contained the methodology and how to upload the results to the online project portals.

Survey Protocols

The original objective was for each site to be visited at least eight times during the active reptile seasons (February/March – September/October) over the years 2022-24, with visits at least two weeks apart. More visits than this could overly disturb the animals. Although focusing on adders, volunteers were asked to record all reptile and amphibian species observed, including all life stages and sloughs (Figs. 2-4).

Fig. 2. Male adder (*Vipera berus*), Scottish Borders, Scotland, March 2022. (Photo: Andrew Mossop)

Fig. 3. Melanistic common lizard (*Zootoca vivipara*), Aberdeenshire, Scotland, 2023. (Photo: Stephen Corcoran)

Fig. 4. Female slow-worm (*Anguis fragilis*), Scottish Borders, Scotland, March 2022. (Photo: Andrew Mossop)

For reptile surveys, weather conditions are crucial to detectability (Prestt, 1971; Sewell *et al.*, 2013; Bauwens & Claus, 2019). Early in the season (January – April) reptiles may be located basking even on relatively cold days (temperatures <10ºC) in sheltered sunny microclimates. However, we recommended that surveyors aimed for warm (from 10–20ºC) overcast days, particularly after a period of heavy rain. We advised surveyors not to survey during extreme weather events or high winds.

At each site we asked the surveyors to complete a roughly circular transect, walking for a period of about three hours (recording their start and end time), moving quietly and slowly scanning the ground and any suitable habitat features looking for animals. Surveyors were particularly asked to check southerly facing banks; sheltered microhabitats; "transitional" areas, e.g. the edge of a path or woodland ride, or at the edge of a scrub belt; and for common lizard basking on timber and rubble.

RESULTS

Table 1 summarises the number of survey visits during the period from 1st April 2022 to 31st March 2024. It should be noted that it was not always possible to achieve eight visits for each site. For some sites there were restrictions on the timing of visits due to forestry

Site Number*	Site Location	No. visits 1992-93	No. visits 2022-23
1a	Sutherland (Highland)	12	3
1b	Sutherland (Highland)	4	3
4	Isle of Skye (Highland)	10	8
5	Ross & Cromarty (Highland)	4	4
6	Isle of Skye (Highland)	4	5
7	Aberdeenshire	3	9
8	Aberdeenshire	5	12
9	Perth & Kinross	8	6
10	Stirling	5	14
11	Arran (Ayrshire & Arran)	3	4
12a	Edinburgh & the Lothians	7	3
12b†	Edinburgh & the Lothians	0	6
13	Ayrshire & Arran	7	3
14	Dumfries & Galloway	4	8
15	Scottish Borders	12	9
16	Dumfries & Galloway	7	4

Table 1. Number of Scottish National Adder Survey visits completed at active sites in 1992-93 and 2022-24. *Based on the 1992-93 survey numbering system with the sites shown in Fig. 1. †A new site adjacent to the original 1992-93 survey area, but not included in the original surveys.

and other operations, and the volunteers found it difficult to predict accurately when weather windows would be favourable which, particularly for the more remote sites, made planning difficult. For these reasons the results presented are based on the efforts of 29 active surveyors.

For each of the sites visited, we plotted peak counts for all amphibians and reptiles observed during the 2022-24 seasons following the protocols of Gardner *et al.* (2019), since different numbers of visits were made to each site (Table 1). Surveyors were asked to record all amphibians and reptiles, and there are records for adder (Fig. 2), common lizard (Fig. 3), slow-worm (Fig. 4), common frog, common toad, smooth newts, and palmate newts. These results are presented in Table 2 and Fig. 5.

DISCUSSION

For each site, all amphibians and reptiles were recorded, with common lizard being most frequently observed, then common toad, adder, common frog, and slow-worm. Smooth and palmate newts were less frequently observed, but this would be expected in what was primarily a visual survey for reptiles, since these species are most often recorded in ponds during the spring breeding season. As this is a visual encounter survey, we would also expect slow-worm to be under-recorded as they are typically cryptic, with a fossorial habit (McInerny, 2014a).

If refugia mats had been used, it is likely that higher numbers of slow-worms and amphibians would have been recorded. Adders were recorded from eight sites (seven of the original sites) in 2022-24, in contrast to the nine sites where adders were recorded in 1992-93. The largest numbers of adders were consistently recorded at Site 8 in Aberdeenshire with a peak count of 12 animals. This site is a national nature reserve, and managed sympathetically for reptiles. These comparative numbers appear to show declines, but with only a few visits to some sites it is hard to confirm absence. A single adder was recorded near some abandoned stone buildings on the trail to the site in north Arran, but as this was not within the 1992-93 survey area (no adders were reported from 1992-93) it was not included in the results. The forested site in the Borders had been a favoured site in the 1992-93, with a total of 48 animals recorded during 12 survey visits. However, the surveyors recorded only a single female adder (observed three times, but possibly the same animal) during nine separate visits in 2022-24. This accords with anecdotal evidence from the original survey team (J. Allan, pers. comm.) that forestry harvesting and extensive clearances of former suitable adder areas has led to the loss of what was previously a strong adder population (or movement of animals to new locations). Similarly, Site 4 in northern Skye, Site 7 near Braemar and Site 13 in Ayrshire & Arran, may have experienced localised changes to their management regimes that have not favoured adders, or caused them to move, making them harder to locate during a visual survey. Though as only a single individual was recorded at both Site 7 and Site 13 in 1992-93, it may be that there were only ever small populations of adders there.

It should also be noted that different surveyors visited the sites, each with differing levels of experience. Therefore, with so few survey visits, a negative sighting may reflect lack of experience, or poor weather conditions causing the animals to shelter out of sight, rather than definitive absence.

It was interesting to note that adders were recorded at the two sites in Edinburgh & the Lothians in the 2022-24 surveys, where they were recorded as absent in 1992-93. On Arran, one surveyor took a different route to the survey site and therefore found an adder at a location not previously visited. In both areas there are opportunistic records from recent years, logged on Record Pool

(www.recordpool.org.uk), and it may be that small adder populations persist in the locality.

Adder declines are likely to be due to a number of causes, primarily habitat loss, but also persecution, predation, disturbance, and burning of their habitat, and these threats may occur simultaneously. Agricultural intensification and commercial forestry are some of the biggest direct causes of adder habitat loss. Adders have suffered more than other widespread reptile species

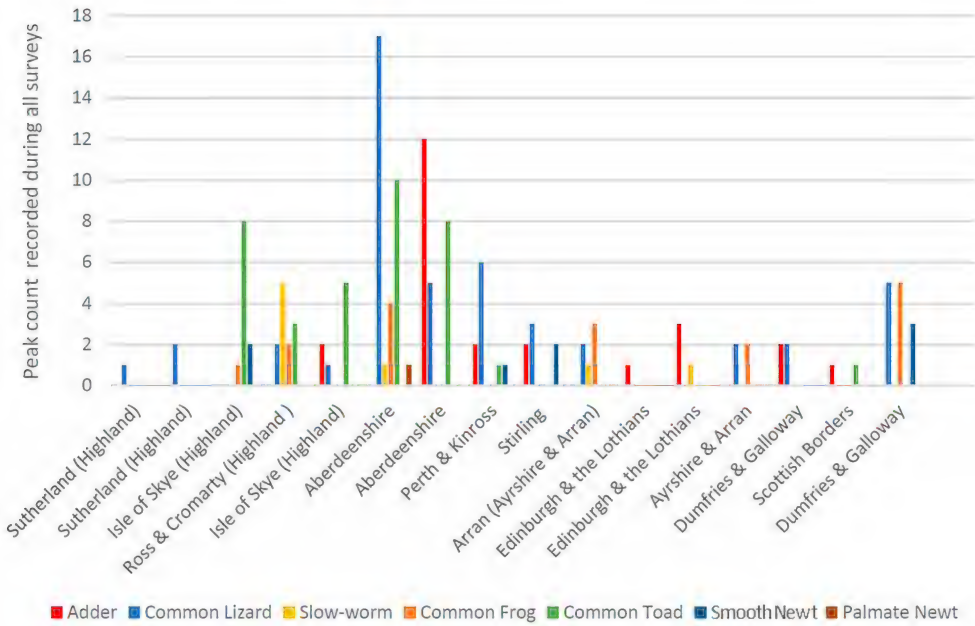

Fig. 5. Peak counts for all amphibian and reptile species at the 16 Scottish National Adder survey sites during 2022-24.

Site number*	Site location	Adder 1992-93	Adder 2022-24	Common lizard 1992-93	Common lizard 2022-24	Slow-worm 1992-93	Slow-worm 2022-24
1a	Sutherland (Highland)						
1b	Sutherland (Highland)						
4	Isle of Skye (Highland)						
5	Ross & Cromarty (Highland)						
6	Isle of Skye (Highland)						
7	Aberdeenshire						
8	Aberdeenshire						
9	Perth & Kinross						
10	Stirling and Forth Valley						
11	Ayrshire & Arran						
12a	Edinburgh & the Lothians						
12b†	Edinburgh & the Lothians						
13	Ayrshire & Arran						
14	Dumfries & Galloway						
15	Scottish Borders						
16	Dumfries & Galloway						

Table 2. Changes in occupancy at the sites (based on presence/absence only) for the three most regularly reported reptile species (adder, common lizard and slow-worm) in the 30 years between the original surveys during 1992-93 and 2022-24. *Based on the 1992-93 survey numbering system with the sites shown in Fig. 1. †A new site adjacent to the original 1992-93 survey area, but not included in the original surveys. Red: adder present; blue: common lizard present; yellow: slow-worm present; grey: site not surveyed; white: reptiles absent.

because, although they have habitat preferences that accord with that found across much of Scotland (*McInerny et al*. 2014b), they have been heavily persecuted in the past and they are less able to colonise new locations when populations recover (Gardner *et al*., 2019). In addition, despite some changes in attitudes by humans, adders are still sometimes deliberately killed, even though this is illegal, further diminishing already small and fragmented populations. Adders also appear to be sensitive to repeated disturbance by recreational site users and photographers (Baker *et al*., 2004).

Even on protected sites adder populations may not persist, as many standard habitat management practices do not favour the species. In some cases, unsympathetic habitat management, particularly widespread clearance of vegetation, over-grazing, burning and extensive scrub management, with the removal of hibernation sites and other important landscape features, can lead to severe declines and local extinctions (Worthington-Hill & Gill, 2019; Law *et al*., 2020). Conversely, lack of positive management, leading to degradation of key microhabitat features and shading of basking areas, may also negatively affect adders.

The results to date provide us with an overview of the status of adders and other species of amphibian and reptile at 16 sites, spread across mainland Scotland, the Isle of Skye and Arran. As this is an ongoing study, it is intended that a more extensive analysis and interpretation will be undertaken once the spring reptile emergence surveys from 2024 and questionnaire data collection are completed. Whilst it is encouraging that adders were observed at comparable or even greater numbers at eight sites (seven of the original sites surveyed in 1992-93), the apparent loss of adders at three of the original sites, and the major declines observed at Site 15 in the Scottish Borders should be a cause for concern. This highlights the importance of on-going monitoring and of obtaining a better understanding of adder distribution and habitat requirements (Prestt, 1971; McInerny, 2014b; Bauwens & Claus, 2019), in order to work in partnership with land managers to reverse any declines and work towards bolstering healthy populations for the future.

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Champhibians, a citizen science programme for schools: a project introduction and case study from Malls Mire Local Nature Reserve in Glasgow, Scotland

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ABSTRACT
Champhibians, the "champions of amphibians," a pond adoption project instigated by Amphibian and Reptile Conservation (ARC), provides an interesting case-study of a citizen science project that was specifically designed for schools. This paper highlights the main aims and benefits of the project by showcasing one of the pilot schools that has participated in the project and adopted a pond at the Malls Mire Local Nature Reserve (LNR) in Glasgow, Scotland. The benefits of this project stem from its links to the school curriculum as well as the connection it establishes between schools, the ARC Trust and managers of local community greenspaces. The importance of outdoor education has long been recognised for benefitting children's mental health and well-being as well as their relationship with nature. It can help to incorporate several of the United Nations Sustainable Development Goals (UNSDGs) into the curriculum, such as life below water, climate action and life on land, while at the same time providing valuable data for land managers through its citizen science approach.

INTRODUCTION
Champhibians is a pond adoption scheme for schools that was developed by Amphibian and Reptile Conservation (ARC), a national wildlife charity committed to conserving amphibians and reptiles. This citizen science project allows schools to work with their own ponds or adopt a nearby pond in the community. The project's primary purpose is for the school to monitor and support the amphibians in their adopted pond. The data collected include information on the general condition of the ponds, water quality indicators as well as recording the animal life within the pond. Citizen science projects, such as the Great Garden Birdwatch by the RSPB (2023) or the Dragons in your Garden recording scheme by ARC (2023), are widespread across the U.K. All of these projects allow for recording on an occasional basis and are highly inclusive, simple and easy to use and require no previous recording experience.

Schools are encouraged to take part in various recording schemes and, although Champhibians is building on these principles, it is to our knowledge the first citizen science project in the U.K. that was specifically designed for schools. It actively links into the Scottish Government's Curriculum for Excellence (CfE) (Education Scotland, 2024), and aims to incorporate regular outdoor education into a school's yearly lesson plan and to build a close relationship between the ARC Trust, land managers and schools. Following the successful piloting of the Champhibian project in Scotland in 2022, it was launched nationwide in February of 2023.

The importance of citizen science is not only to gain broader survey data (de Sherbinin *et al*., 2021), but also to increase the understanding of species biodiversity within the wider community. This is especially important for communities in areas of socio-economic deprivation, as they face additional barriers to participating in these programmes (Hobbes & White, 2012). These barriers include a lack of opportunities, lack of accessibility and the perceived cost and knowledge required to participate.

Through ARC's pond adoption scheme, children can become more familiar with their local amphibians. As there are only seven native amphibian species in the U.K., it is relatively easy to study these animals, which can help to reduce perceived barriers like accessibility due to a lack of knowledge. The children and their teachers learn how to recognise amphibians, and how different species live and survive, and they learn about the threats amphibians face and how they can help to protect them, including habitat management. Amphibians are considered to be the most threatened vertebrate class on a global scale (Stuart *et al.*, 2004), though in Europe they appear to share this high level of threat with several other vertebrate groups (Beebee *et al.*, 2009). The need for more long-term monitoring has been identified alongside the need for habitat enhancement in the context of Scottish conservation (Downie *et al.*, 2019), and Champhibians can contribute to these goals.

The data gathered by the schools can be used to create regional hubs for sharing and mapping the species of several schools that are located in the same area. Land managers of the adopted ponds can also benefit from these data and the survey records generated by the schools. The online portal also facilitates the creation of

charts and introduces simple data-handling techniques at levels suitable for each age group. As the results for each school can be linked across the Champhibian network, individual and regional results can be analysed and reviewed, giving each school access to more data they can work with. Over a few years, the data sets will become more interesting and comparison techniques can be introduced and utilised.

CHAMPHIBIANS AT MALLS MIRE

St. Brigid's primary school in Toryglen, Glasgow was one of three pilot schools across Scotland that were chosen for this project. As St. Brigid's does not have a pond in their own school grounds, they chose to adopt a pond at Malls Mire Local Nature Reserve (LNR), which is managed by Urban Roots, a community-led environmental charity. The Malls Mire Community Woodland has been a Local Nature Reserve since 2012, with an expansion planned for 2023 (Digruber, 2023). This expansion will include the Sustainable Drainage Systems (SuDs) ponds and wetland area, which is home to a healthy population of frogs.

Urban Roots have been working with local schools and nurseries to help children connect to their local greenspaces. Being able to work with ARC on the Champhibian project has been a great opportunity for Urban Roots to strengthen their ties with the local education providers as well as local children and their families. Programmes such as Champhibians tie in directly to the charity's mission of connecting the local community to their greenspaces, delivering outdoor education and encouraging pro-environmental behaviour.

St. Brigid's has had several visits in 2023 to the ponds at Malls Mire, where they have been able to pond dip with the support of ARC and Urban Roots (Fig. 1). A science day was organised at Malls Mire on 8th June 2023 to coincide with the Glasgow Science Festival and the Scottish Herpetological Conference organised by The Glasgow Natural History Society (Downie *et al.*, 2024). This involved St.Brigid's Champhibian classes as well as Toryglen primary school, who have also signed up to the Champhibian project as a result of the close partnership with Urban Roots. Two local nursery schools were also invited to learn about ponds, amphibians and the wider biodiversity on their doorstep. Throughout the day 100 children were introduced to the SuDs pond at Malls Mire and learned how to pond dip and identify froglets (*Rana temporaria*) alongside various families of aquatic invertebrates (Fig. 2).

SUPPORTING THE CURRICULUM FOR EXCELLENCE

Champhibians is intended to be an enjoyable and engaging educational experience, with opportunities to fulfil many of the requirements for Learning for Sustainability from the Scottish CfE through a coherent, rewarding and transformative learning experience. It helps to embed regular outdoor education sessions into a school's yearly lesson plan and through its collaborative approach builds a legacy where the results

Fig. 1. Pupils of St. Brigid's Primary School pond-dipping at the Malls Mire SuDS pond, Glasgow.

Fig. 2. Frog found by the school children at the Malls Mire ponds.

of each year show development and change.

There are many opportunities to expand from the simple surveying activity to cover the three core areas for learning and thus link the outdoor sessions back to class-based learning goals. Describing habitats and ponds helps to develop language and literacy skills, while dealing with data from surveys aids numeracy. Communication of this information in an inclusive and accessible way is also part of the learning experience (Fig. 3). Health and well-being skills are gained by being in a natural environment and by learning about risks and safe pond-dipping practices.

Through hands-on citizen science, the four capacities that form part of the CfE are achievable. These four capacities are for children to become: successful learners, confident individuals, effective contributors, and responsible citizens.

Through Champhibians, children are learning to be scientists, who monitor and care for the world. They learn as individuals and as a team about their responsibilities as surveyors and how to survey with respect for life. The processes and procedures of being a Champhibian are to be a citizen scientist and a responsible citizen at the same time.

Fig. 3. Janet Ullman at Malls Mire demonstrating pond-dipping to local school children.

BENEFITS FOR COMMUNITY GREENSPACES

Some of the children who have a connection to Urban Roots and the Malls Mire LNR through the Champhibian project have then attended other outdoor education and play activities. The contact with the schools has also allowed Urban Roots to bring classes and their teachers to the woodland for John Muir award sessions as well as other bushcraft activities. The teachers have been more confident in bringing the children to Malls Mire and, as a result, the children have had an increased amount of outdoor learning opportunities in the community woodland. This local impact through collaboration and community engagement is important to help create a sense of place for young children as well as their families, thus helping communities to value their local area and feel better connected. The outdoor education and time spent in local greenspaces are helping to increase environmental awareness and can foster pro-environmental behaviour from a young age. The long-lasting connection between the schools and local conservation managers enables opportunities for volunteering to enhance local habitats and biodiversity and the data collected by the school can help inform management plans.

FUTURE PLANS

Following the successful pilot projects of Champhibians in Scotland and the rollout across the U.K., schools will be encouraged to survey as much or as little as they can. Community spaces like Malls Mire can act as hubs for several Champhibian schools to work together and collaborate with the support of ARC staff and land managers. This collaboration with community greenspaces can facilitate relationships with nurseries that are feeding into the primary schools as well as young people from local high schools. This will allow schools access to larger amounts of data, even if they are limited in the number of times they can visit a pond themselves.

Building on an existing partnership with the Scottish Rural College (SRUC), Urban Roots will work with an HND cohort and their lecturer on bespoke outdoor education lesson plans for Champhibians. This will be based on a very engaging superhero theme, which was trialled at Malls Mire in 2023 with several classes from a local primary school. These lesson plans can then be utilised across the various schools and tie in well with the Champhibian superhero mascot "Newtrino" (Fig. 4).

Fig. 4. The Champhibians superhero mascot "Newtrino".

CONCLUSION

The pilot project of Champhibians at Malls Mire has highlighted the potential of this citizen science project to increase the time children spend actively engaged with outdoor education while facilitating and enhancing partnerships between schools, land managers and the ARC trust. Supporting schools and teachers with resources and opportunities to engage in science, technology, engineering and maths (STEM) topics in their local area can be an important tool to incorporate sustainability and environmental awareness into the curriculum in a fun and engaging way. It is also very beneficial for local community greenspaces as it contributes to many of the outreach and education activities already taking place and enables land managers to build and strengthen their ties with local schools.

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The short-term impact of Eurasian beavers (*Castor fiber*) post-reintroduction on amphibian abundance and diversity in a lentic environment

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ABSTRACT
In 2021, eight Eurasian beavers (*Castor fiber*) were reintroduced into the Idle Valley Nature Reserve (IVNR), Nottinghamshire, England. Amphibian surveys were conducted in four areas within the IVNR prior to the beaver reintroduction to establish baseline data. To investigate the short-term impact of beavers on amphibian abundance and diversity, this study sampled the same four areas post-beaver reintroduction. An additional four areas were also sampled post-beaver reintroduction, to compare areas where beaver activity was present or absent. Furthermore, environmental and beaver-linked variables were analysed to predict adult amphibian abundance. Adult amphibian abundance dramatically increased post-beaver reintroduction. However, there were no significant differences in adult amphibian abundance between areas where beaver activity was present or absent, with only increasing water depth and surveying at night shown to be significantly positively related to adult amphibian abundance. Conversely, there was a significant difference in terms of environmental variables between areas where beaver activity was present or absent. Similarly, beaver active areas were found to have higher young amphibian recruitment. Thus, the reintroduction of the beavers has not had a negative short-term impact on amphibian diversity and abundance, with the findings suggesting that over time the beavers will have a positive impact.

INTRODUCTION
A species is typically reintroduced to improve the conservation status of that species (Seddon *et al*., 2007), but the reintroduction of some species can be used as a management tool to recover overall species richness of release sites, develop habitat quality or to enhance ecosystem function (Stringer & Gaywood, 2016). Many release sites that could benefit from enhanced ecosystem function are in freshwater ecosystems (Romansic *et al*., 2021), which are increasingly damaged by anthropogenic threats such as pollution, water removal, agricultural runoff, invasive species, and climate change (Naiman & Dudgeon, 2011; Reid *et al*., 2019). To counteract these anthropogenic threats and restore streams, riparian and lentic areas, some environmental managers in the northern hemisphere are using the reintroduction of American beavers (*Castor canadensis*) or Eurasian beavers (*Castor fiber*) as site management tools (Romansic *et al*., 2021).

Historically, Eurasian beavers were distributed throughout much of Europe and large portions of Asia including China and Mongolia (Durka *et al*., 2005). Due to overexploitation in the 17th century, there was a dramatic decline in the beaver populations, with only eight small populations surviving across Europe (Dalbeck *et al*., 2007). Through reintroduction programmes, natural dispersion, and increased protection across Europe, the beaver population has increased from 1,200 individuals a century ago to an estimated 1.5 million currently (Halley *et al*., 2021). In the U.K., beavers were hunted to extinction by the 16th century (Gaywood *et al*., 2015). However, through reintroduction programmes in the last 20 years, the current Scottish beaver population is estimated to be more than 1,000 individuals (Campbell-Palmer *et al*., 2021). The Scottish beaver population originates from the first British beaver trial in Knapdale, Argyll in 2009, where three families were released, along with unofficial beaver release in the River Tay catchment in 2001 (Campbell-Palmer, 2018). Unofficial releases have also been suspected in England: the origin of the River Otter population in Devon is unknown, with the beavers thought to have been released around 2008 (Halley *et al*., 2021). Investigations into the impact of both unlicenced populations concluded with the beavers being allowed to stay, due to evidence of their significant ecological benefits and ecosystem engineering ability (Brazier *et al*., 2020).

A species is considered an ecosystem engineer if it creates, modifies, or maintains habitats (Jones *et al*., 1994). Through tree-felling and browsing, along with the construction of lodges, burrows, canals, and dams, beavers have been shown to shape landscapes, affecting community and ecosystem levels on multiple spatial scales (Rosell *et al*., 2005). In lotic freshwater habitats, stream damming is arguably the most significant beaver

activity (Brazier *et al.*, 2020). By damming streams, structural heterogeneity increases due to the increase in wetlands and ponds, turning the environment into a lentic habitat (Nummi & Holopainen, 2020). The impact of beavers on existing lentic environments is less studied. However, within these environments, water bodies are connected through the creation of beaver canals (Grudzinski *et al.*, 2020). In both environments, beaver activity alters local hydrology, geomorphology, and geochemistry (Brazier *et al.*, 2021). Beaver activity also causes shallow areas of water bodies to increase in temperature because formerly shaded areas receive higher light levels due to the felling and drowning of trees (Skelly & Freidenburg, 2000). Increased insolation in shallow sections leads to the growth of submerged and emerging vegetation (Ray *et al.*, 2001). The drowned trees and standing deadwood increase the amount of coarse woody debris (CWD) which in turn leads to an increase in macroinvertebrate species richness and abundance (Washko *et al.*, 2022). Macroinvertebrates are not the only class of animal found to have increased species richness and abundance in proximity to beaver-modified habitats: mammals, birds, fish, and amphibians also have a positive association with beaver ponds, lodges, and canals (Grudzinski *et al.*, 2020; Law *et al.*, 2016; Tye *et al.*, 2021).

Partly due to their water requirements, amphibians have repeatedly been shown to benefit from beaver activity (Cunningham *et al.*, 2007). Beaver canals and ponds have been reported to improve landscape connectivity and habitat heterogeneity for amphibians, leading to increased dispersal and colonisation of new breeding sites (Anderson *et al.*, 2015). Beaver-present ponds also have higher young amphibian recruitment than beaver-absent ponds (Stevens *et al.*, 2007). Stevens *et al.*, (2007) hypothesised that the higher young amphibian recruitment was due to the high stable temperatures in beaver ponds as well as the increased protection provided by beaver activity (Dalbeck *et al.*, 2014). In shallow pond edges, the increased CWD and submerged vegetation from beaver activity provide shelter for amphibians, aiding in predator avoidance (Janiszewski *et al.*, 2014). Beaver activity may also alter water chemistry and amplify nutrient content, leading to increased food supply for amphibian larvae (Brönmark & Hansson, 2017). However, beaver activity can negatively impact amphibians with flooding of hibernacula as a result of damming or mass death of eggs and larvae when beavers abandon ponds (Bashinskiy, 2014).

The overall positive relationship between amphibians and beaver activity is important due to the global decline and extinction of amphibians since the 1970s (Stevens *et al.*, 2007). Between 1970 and 2014, amphibian populations in temperate environments are estimated to have decreased 2.8% per year, which is a greater rate of decline than that shown by any other vertebrate group (Leung *et al.*, 2017). Many factors have contributed to the amphibian decline, including habitat loss and alteration, often cited as the foremost causes (Cushman, 2006; Gallant *et al.*, 2007). Therefore, with beavers creating and modifying habitats that are suitable for amphibians, it is unsurprising that a meta-analysis of articles investigating the relationship between beavers and biodiversity found that 80% described a positive effect of beaver activity on anurans (Stringer & Gaywood, 2016). Of the 18 articles included in the meta-analysis, only three studied the impact of Eurasian beavers, with the remainder on American beavers (Stringer & Gaywood, 2016). The amphibian fauna in North America comprises many stream-dwelling species (Morrison & Hero, 2003), whereas in Europe amphibians prefer lentic environments (Dalbeck *et al.*, 2020). Therefore, despite the similarities between the beaver species, their impact on amphibians may differ due to differences in life-history traits (Stringer & Gaywood, 2016). However, a literature review based purely on studies conducted in Europe reported that all 19 amphibian species known to inhabit central temperate and boreal Europe were found in beaver ponds, despite their diverse ecological needs (Dalbeck *et al.*, 2020).

Limited research has been carried out on the relationship between beaver activity and amphibians within the U.K., although both the Scottish and Devon beaver trials have suggested a positive impact (Brazier *et al.*, 2020; Downie *et al.*, 2019). From mainland European studies, generalists and woodland species, compared to "open country" and pioneer species, benefitted the most from beaver-modified habitats (Dalbeck *et al.*, 2020). Therefore, if these results were applied to the British amphibian community, the common frog (*Rana temporaria*), the common toad (*Bufo bufo*), and the palmate newt (*Lissotriton helveticus*) would be expected to benefit the most from beaver activity (Beebee, 2014). For example, Dalbeck *et al.* (2014) demonstrated that beaver ponds are preferred oviposition sites for common frogs in Germany, due to high insolation and a stable hydroperiod causing faster tadpole development. Furthermore, the Devon beaver trial reported an increase in common frog spawning from 10 to 681 over a six-year period after the beaver reintroduction (Brazier *et al.*, 2020).

The great crested newt (*Triturus cristatus*) and the smooth newt (*Lissotriton vulgaris*) would also be expected to benefit from beaver activity, but to a lower degree and based on European findings the natterjack toad (*Epidalea calamita*) would not be affected (Beebee, 2014; Dalbeck *et al.*, 2020). Although more research is needed to draw firm conclusions, mainland European studies suggest that species with the highest conservation concern in the U.K., the great crested newt (Biggs *et al.*, 2015) and the natterjack toad (Buckley & Beebee, 2004) might not benefit significantly from beaver reintroductions (Dalbeck *et al.*, 2020). While the common frog and the common toad are not the highest conservation concern in the U.K., since the 1970s their populations have been declining and increased conservation efforts are needed (Beebee, 2014). The common toad, in particular, has declined

dramatically in the last 30 years, with a 68% decrease in population (Petrovan & Schmidt, 2016).

One of the main causes of amphibian decline in the U.K. is habitat loss, with many wetlands drained, and rivers canalised over the last two centuries (Oertli, 2018). By draining wetlands and controlling water courses, the natural formation of new ponds has decreased significantly (Oertli *et al.*, 2010). On the other hand, many man-made pond systems in modern Britain are former gravel pits (Oertli, 2018). In France, flooded gravel pits have been shown to support a high proportion of amphibian species on a regional scale (Zamora-Marín *et al.*, 2021), with a similar relationship suggested to occur in the U.K. (Buckley *et al.*, 2014). Former gravel pits have also been found to support high macroinvertebrate diversity and abundance, again supporting the notion of wetland gravel pits being important amphibian habitats (Santoul *et al.*, 2004).

A large area of the Idle Valley Nature Reserve (IVNR) in Nottinghamshire, England comprises a former gravel pit that has been transformed into a wetland system. In 2021, eight Eurasian beavers were reintroduced into the enclosed gravel pit wetland system by the Nottinghamshire Wildlife Trust, with the aim of using the beavers as a management tool to benefit wider species recovery plans in Nottinghamshire. One of the objectives of the reintroduction project is to monitor the long-term impact of beavers on amphibian diversity and abundance. Prior to the beaver reintroduction, a baseline amphibian survey was conducted (Woods, 2021). Therefore, the IVNR beaver reintroduction offers an opportunity to investigate both the short-term and long-term impact of beaver activity on amphibians in a man-made lentic environment, with amphibian surveys conducted before and after beaver reintroduction. Previous studies investigating the impact of beaver activity on amphibians have focused on the long-term effect and have been conducted primarily in lotic environments, with no published papers having investigated the short-term impact after reintroduction in an area sampled prior to beaver reintroduction. Furthermore, there has been no published work from the U.K. investigating the impact of beavers on native amphibian species abundance and diversity.

Woods (2021) conducted amphibian surveys in four areas within the IVNR in 2021, prior to the beaver reintroduction. One year later, after the beaver reintroduction, the study reported here sampled the same four areas, plus an additional four areas, to (1) draw comparisons between 2021 and 2022 in terms of amphibian abundance and diversity, and (2) compare amphibian abundance and diversity in areas where beaver activity was present to areas where beaver activity was absent. This paper provides insight into the relationship between amphibians and beavers within the U.K. and highlights the potential short-term impact of beavers, as well as providing a continuation plan for amphibian monitoring within the IVNR beaver enclosure.

METHODS

Study site

In November 2021, four adult Eurasian beavers (two males and two females) and four kits (two males and two females) from the Tayside beaver population, were released in a 60 ha enclosed conservation area. The release site is in the northeast of the Idle Valley Nature Reserve (IVNR), Retford, Nottinghamshire (Fig. 1), owned and managed by the Nottinghamshire Wildlife Trust. To keep the beavers within the release site, the area is fenced off and therefore not accessible to the public. The lakes within the site were historically sand and gravel pits. Vegetation within the enclosure is an assortment of successional woodland, scrub, and meadow, maintained by periodic grazing of cattle, wild roe deer (*Capreolus capreolus*), and Reeves' muntjac deer (*Muntiacus reevesi*). The woodlands consist of willow (*Salix* spp.), alder (*Alnus* spp.), and birch (*Betula* spp.) trees (Howard, 2020). Based on Retford amphibian accounts, the highest number of expected native amphibian species within the site is four: common frog, common toad, smooth newt, and great crested newt (Osborne, J., pers. comm.; Woods, 2021).

Amphibian surveys

Between April and June 2021, prior to the beaver reintroduction, Woods (2021) used visual encounter surveys to assess amphibian abundance and species richness within the study site. In June 2022, post-beaver reintroduction, the amphibian surveys were repeated for this investigation. Six amphibian survey visits were conducted in both 2021 and 2022. A survey visit involved sampling each area once during daylight between 16:00 and 19:30 and once at night between 21:40 and 01:40. Areas 1, 2, 3 and 8 were sampled by Woods in 2021 and by this investigation in 2022 (Fig. 2). Woods (2021) selected these areas using QGIS 3.14, by randomly generating four potential sampling areas within the study site then selecting the closest suitable area in terms of habitat quality and practicality of access. In 2022, from these areas, only area 3 contained signs of beaver activity. To obtain an even number of areas where beaver activity was present and absent, four additional areas were selected to be surveyed in 2022. During the surveys for this investigation, beaver activity was present in Areas 3, 5, 6, and 7 and was absent in areas 1, 2, 4, and 8 (Fig. 2). The presence or absence of beaver activity was determined by signs of beaver activity, including beaver-gnawed trees and branches (Cunningham *et al.*, 2007). The location of each area was recorded using a GPS Garmin GpsMap 64.

For both this investigation and the study by Woods (2021), two surveyors spent ten minutes searching for young and adult amphibians along the water's edge and surrounding habitat in each area. For the purpose of this investigation, "young amphibian" refers to froglets, toadlets and juveniles. "Adult amphibian" refers to individuals that are fully formed and a sufficient size, based on the life-stage species size guide obtained from Beebee (2013). The number and species of each observed adult amphibian were recorded. Species were

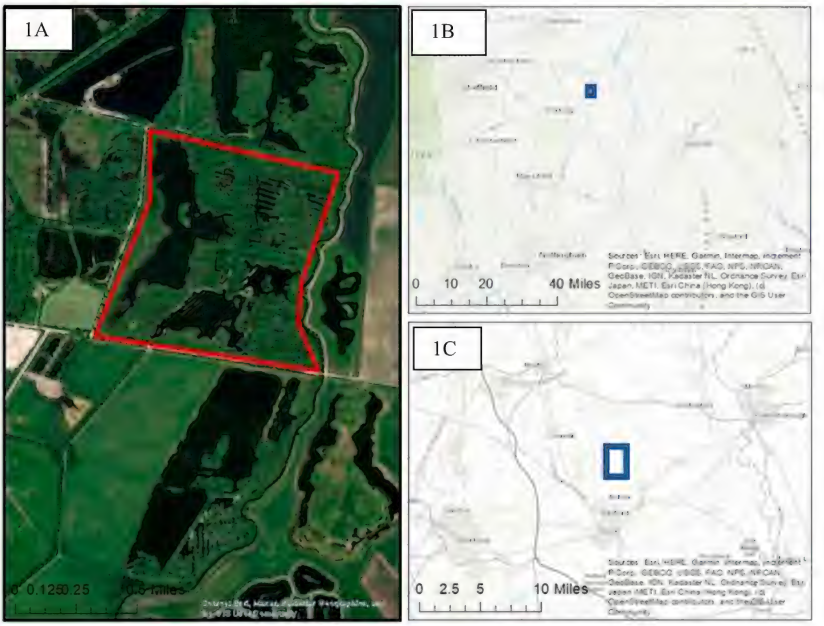

Fig. 1. A-C. The location of the Idle Valley Nature Reserve (IVNR) in Nottinghamshire, England. Blue rectangles on maps B and C highlight the location of the IVRN. The red outline in A outlines the fence of the beaver enclosure within the IVNR.

Fig. 2. The beaver release site located within the Idle Valley Nature Reserve, Nottinghamshire. The red outline represents the fence of the enclosed site. Each dot is an area where amphibian surveys were carried out along with area number in the white circles. Areas 1 (53.37103, -0.933473), 2 (53.367648, -0.936508), 3 (53.367518, -0.935176) and 8 (53.364781, -0.939126) (orange) were sampled by Woods in 2021 (Woods, 2021) and by this investigation in 2022. Areas 4 (53.366015, -0.930965), 5 (53.367683, -0.932267), 6 (53.367784, -0.930834) and 7 (53.369116, -0.929883) (green) were sampled in 2022. In 2022, beaver activity was present in areas 3, 5, 6 and 7 and beaver activity was absent in areas 1, 2, 4 and 8.

identified using the key from Beebee (2013). The number of young amphibians encountered was recorded in three categories: 0, 1-24 and 25+, as it was difficult to accurately count more than 25 mobile young amphibians. For the same reason, young amphibians were not identified to species level. During night visits, a million-candle power torchlight was used. The protocol and procedures employed in this study were approved by the Nottingham Trent University School of ARES Ethical Review Committee.

Area characterisation

Environmental variables and variables linked to beaver activity were recorded based on the variables collected in similar studies (Table 1). During each visit to an area, water temperature, water pH and water Total Dissolved Solids (TDS) were recorded using a Hanna Combo device, model HI 98129 from the closest body of water (Bashinskiy & Osipov, 2016) and signs of beaver activity were recorded as present or absent. The average canopy cover and average water depth 1 m from shore were recorded once for each area (Romansic *et al.*, 2021). Signs of beaver activity included beaver-gnawed trees and branches (Cunningham et al., 2007). Canopy cover was recorded using the iOS %Cover application (Public Interest Enterprises) on an iPhone 7 (Model A1778). At the start and end of each survey, air temperature was recorded using a weather gauge (Cunningham *et al.*, 2007). Beaver presence was not included as a variable as no beavers were seen during the surveys.

Data analysis

Abundance was expressed as the number of individuals encountered in an area per visit (Romansic *et al.*, 2021). Species richness was expressed as the number of species occupying an area per visit (Romansic *et al.*, 2021). The data analysis was carried out using the software R (Version 4.2.0). To validate the underlying assumptions of the chosen statistical tests, a data exploration process was performed for each objective, following the guidelines of Uzal *et al.* (2020). To compare the adult amphibian abundance between the 2021 amphibian surveys and the 2022 surveys a Wilcoxon test was used because the data were paired and not normally distributed. A Wilcoxon test was also used to compare adult amphibian abundance in area 3 between the 2021 and 2022 surveys. A Mann-Whitney test was performed to compare the adult amphibian abundance in 2022 between areas with beaver activity present to areas with beaver activity absent in 2022, as the data were unpaired and not normally distributed. To compare the environmental variables of water temperature, pH, total dissolved solids (TDS), and average water depth in areas where beaver activity was present to areas where beaver activity was absent, a Mann-Whitney test was also performed.

To investigate the relationship between adult amphibian abundance and environmental variables and variables related to beaver activity in 2022, a Poisson GLMM was performed. A Poisson GLMM was selected as the data were not normally distributed and had a high proportion of zeros. Collinearity issues were identified using a correlation matrix with corresponding pairplots and were confirmed using the variance inflation factor (VIF). The covariate with the highest VIF value was removed until all the VIF values were below 3 (Craney & Surles, 2002). This process resulted in the covariates

Variable	Description and inclusion justification	Data type	Units/categories
Air temperature	The average air temperature throughout the survey (Woods, 2021; Cunningham *et al.*, 2007).	Continuous	°C
Water temperature	Temperature of nearest water body (Woods, 2021; Bashinskiy & Osipov, 2016).	Continuous	°C
Water pH	The pH of the nearest water body (Woods, 2021; Bashinskiy & Osipov, 2016).	Continuous	Logarithmic
Water TDS	The TDS of the nearest water body (Woods, 2021; Bashinskiy & Osipov, 2016).	Continuous	Parts per million (ppm)
Average water depth 1 m	The average water depth 1 m from the shoreline with 5 samples taken at each area (Romansic *et al.*, 2021).	Continuous	cm
Average canopy cover	The average canopy cover 1 m in from the shoreline with 5 samples taken at each area (Romansic *et al.*, 2021).	Categorical	Dense/mid-dense/sparse/very sparse
Beaver activity	Signs of beaver activity such as gnawed trees or branches (Romansic *et al.*, 2021).	Categorical	Present/absent

Table 1. Description and scale of environmental and beaver related variables recorded from eight amphibian survey sites within the Idle Valley Nature Reserve, Nottinghamshire, England.

air temperature, TDS, and canopy cover not being included in the final model. Sample area was included in the final model as a random factor to account for the dependency in the data. Based on AIC values, the GLMM was shown to fit the data better than a model that did not include sample area or a model that included sample area as a fixed term. The GLMM was not over-dispersed. To investigate model misfit due to a potential excess of zeros, simulations of the fitted model were generated. The number of zeros in the simulated datasets was shown to correspond well to the raw data. To investigate the association between the categorical variables of young amphibian abundance and beaver activity in 2022, a chi-square test was performed.

RESULTS

Six surveys were conducted between 14/06/22 and 29/06/22, each comprising visiting the eight selected areas twice. Therefore, in total, there were 96 observations in the 2022 data. The average air temperature during the amphibian surveys was 20°C.

Amphibian abundance and species richness: comparison of 2021 and 2022

In 2021, across areas 1, 2, 3 and 8, 11 adult amphibians were encountered: 10 (91%) common frog and 1 (9%) common toad (Woods, 2021). In 2022 in the same areas, 71 adult amphibians were encountered, with 57 (80%) common frogs, 13 (18%) common toads, and 1 (2%) smooth newt. The abundance of adult amphibians encountered in the areas sampled by Woods (2021) was significantly higher in 2022 (Wilcoxon test, W = 52, n = 48, $P < 0.001$). The species richness also increased from two species to three species. Area 3 was the only area to be sampled in both years that showed signs of beaver activity after beaver reintroduction. In area 3, one adult amphibian was encountered in 2021 and 31 adult amphibians in 2022, a significant increase in adult amphibian abundance (Wilcoxon test, W = 2, n = 12, $P < 0.05$). The species richness also increased from 1 to 3 in area 3.

Comparison between adult amphibians in beaver activity present/absent areas

In 2022 there were 108 adult amphibian encounters across the 12 visits to the eight sample areas, with 86 (80%) common frogs, 20 (18%) common toads and 2 (2%) smooth newts. In areas where beaver activity was present (areas 3, 5, 6, and 7), 64 adult amphibians were encountered: 52 (81%) common frogs, 11 (17%) common toads, and 1 (2%) smooth newt. In areas where beaver activity was absent (areas 1, 2, 4 and 8), 44 adult amphibians were encountered: 34 (77%) common frogs, 9 (21%) common toads, and 1 (2%) smooth newt. Adult amphibian abundance was not significantly higher in areas where beaver activity was present compared to areas where beaver activity was absent (Mann-Whitney test, W = 981, n =48, $P = 0.2$).

Relationship between environmental variables and beaver activity

Median water temperature was significantly higher in areas where beaver activity was absent (21°C) compared with areas where beaver activity was present (19.8°C) (Mann-Whitney test, W = 1474, n =48, $P = 0.02$). The temperature range in areas where beaver activity was absent was 29.6-10.7°C. The range where beaver activity was present was 26.7-17.2°C. The median water pH of 8.86 in areas where beaver activity was absent was significantly higher than in areas where beaver activity was present (7.68) (Mann-Whitney test, W = 1994, n =48, $P < 0.001$). Total dissolved solids (TDS) and water depth were significantly higher in areas where beaver activity was present compared to areas where beaver activity was absent (Mann-Whitney test, W = 564, n =48, $P < 0.001$; Mann-Whitney test, W = 442, n =48, $P < 0.001$).

Relationship between adult amphibian abundance and environmental and beaver linked variables

A Poisson GLMM was fitted to the 2022 data to predict adult amphibian abundance within Idle Valley Nature Reserve beaver enclosure, with sample area fitted as a random term. Observed Adult amphibian abundance was significantly higher at night ($P < 0.001$). There was also a significant positive relationship between amphibian abundance and average water depth ($P = 0.023$). There was no significant relationship between adult amphibian abundance and water temperature, pH, or beaver activity.

Young amphibian recruitment in areas where beaver activity is present and areas where beaver activity is absent

Across the 12 visits to each area, young amphibians were present 48% of the time. When young amphibians were encountered, 68% of the encounters were during the daylight sampling periods. Young amphibian presence was recorded 58% of the time in areas where beaver activity was present. One to 24 young amphibians were encountered 33 times, with 48% in areas where beaver activity was present. The category of "25+ young amphibians" was recorded on 13 occasions, with 85% of these encounters in areas where beaver activity was present (Fig. 3). The association between the number of young amphibians per area visit and the presence or absence of beaver activity was significant ($X^2(2, N = 96) = 8$, $P = 0.02$).

DISCUSSION

Adult amphibian abundance was found to have increased substantially post-beaver reintroduction, with the species richness remaining the same. However, the increase in adult amphibian abundance between 2021 and 2022 could be due to several factors such as natural amphibian population fluctuations and hotter temperatures in 2022. Moreover, there were no significant differences in adult amphibian abundance between areas where beaver activity was present and areas where beaver activity was absent, with only increasing water depth and surveying at night significantly positively related to adult amphibian abundance. There was a significant difference between areas where beaver activity was present and areas where beaver activity was absent in terms of environmental variables, which could partly explain the significant

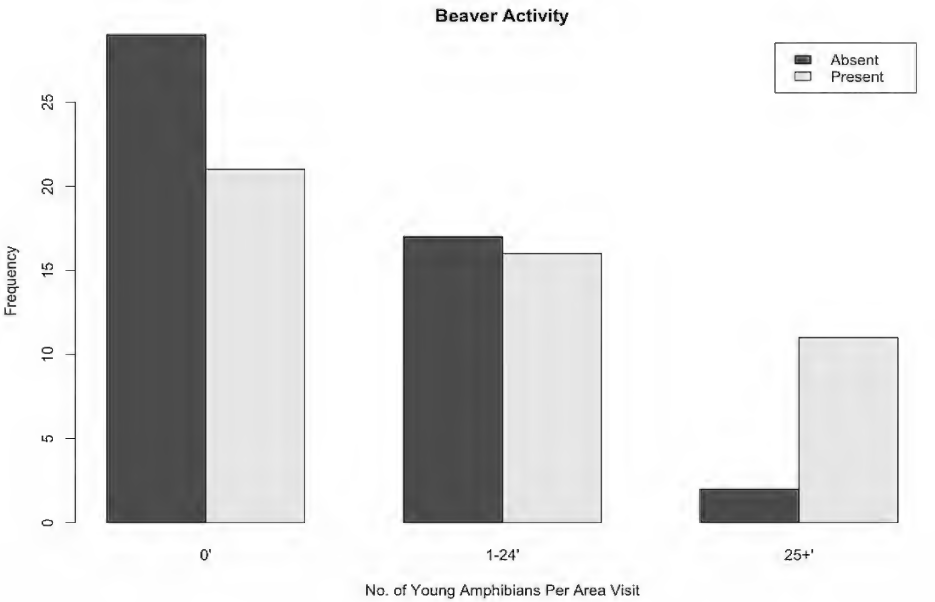

Fig. 3. Frequency of young amphibian abundance with three categories: 0 young amphibians, 1-24 young amphibians and over 25 young amphibians, encountered per area visit in areas where beaver activity was present (grey) and areas where beaver activity was absent (black)

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association between beaver activity and young amphibian abundance, with the vast majority of 25+ young amphibian encounters occurring in areas where beaver activity was present.

Amphibian population fluctuations mostly follow an episodic recruitment pattern, with populations found to naturally decrease in most years and then increase exponentially in favourable years (Alford & Richards, 1999). Therefore, 2022 could be a favourable year, explaining the dramatic increase in both adult common frogs and common toads in 2022 compared to 2021 (Woods, 2021). Furthermore, favourable years for common frogs and common toads have been linked to increased air temperature, with higher growth rates and rapid metamorphosis in warmer conditions (Laugen *et al.*, 2003; Merilä *et al.*, 2000). For example, Sewell *et al.* (2010) conducted amphibian surveys in two contrasting British landscapes over two years. In both landscapes, occupancy rates were significantly lower for common frogs and common toads during 2008 which was notably cooler than 2007. The average air temperature during Woods (2021) surveys was 11°C, while the average temperature during this investigation was 20°C. The difference in temperature could be due to the surveys of this investigation taking place slightly later in the year than Woods (2021). However, the average monthly temperature across England was hotter from January to June in 2022 than in 2021 suggesting favourable conditions for amphibian populations.

The increase in adult amphibian abundance between 2021 and 2022 could also be partly attributed to the reintroduction of beavers. In area three, the only area sampled by both this investigation and Woods (2021) where beaver activity was present, amphibian abundance significantly increased, and species richness increased from one species to three. The positive impact of beaver activity on amphibians in other countries has been well documented. However, previous investigations sampled areas where beavers have been for several years (Dalbeck *et al.*, 2007; Dalbeck *et al.*, 2014; Romansic *et al.*, 2021) whereas this study investigated the short-term impact post-reintroduction. The difference in timescale may explain why there was no significant difference in adult amphibian abundance between areas where beaver activity was present and areas where beaver activity was absent, although areas where beaver activity was present had slightly higher abundance. Therefore, it can be concluded that amphibians are, at the least, continuing to occupy areas that have been altered by beavers at the same rate as unmodified areas, demonstrating that the beavers have not had a negative short-term impact on amphibian abundance and diversity. By continuing amphibian surveys as part of the monitoring plans in the Idle Valley Nature Reserve (IVNR), it will become clearer whether beavers are having a positive impact or if the increases seen in 2022 were due to a favourable year, allowing for an accurate assessment of amphibian demographic trends (Salvidio, 2009).

Unlike amphibian abundance, water temperature was significantly different between areas where beaver activity was present compared to areas where beaver activity was absent. The beaver activity of felling trees increases water temperature, both through increasing sunlight from lower canopy cover and insolation (Ray *et al.*, 2001; Skelly & Freidenburg, 2000). In contrast, for this investigation, the median water temperature was slightly higher in areas where beaver activity was absent. Beaver activity could still have increased water temperatures in the areas where beaver activity was present, but due to a lack of before and after water temperature readings, the true effect is unknown. In areas where beaver activity was absent, the range of temperature was much larger than in areas where beaver activity was present. Increased insolation and drowning vegetation have been suggested to maintain water temperatures within beaver ponds (Dalbeck *et al.*, 2014). Water bodies with less fluctuating temperatures have also been linked to rapid tadpole emergence (Stevens *et al.*, 2007). However, water temperature was not significantly related to adult amphibian abundance. The positive association between amphibian abundance and water temperature has previously been recorded through counting egg masses and not adult occupancy rates, with the differences in methodology potentially explaining the lack of significance for this study (Gollmann *et al.*, 2002; Stevens *et al.*, 2007). Therefore, to investigate the impact of beavers on amphibian abundance and diversity within the IVNR, egg mass counting should be included in the future monitoring programme along with the continuation of recording water temperature.

As with water temperature, beavers have also been shown to alter water pH (Vehkaoja *et al.*, 2015) and amphibians are sensitive to changes in pH (Azizishirazi *et al.*, 2021). The water pH was significantly lower in areas where beaver activity was present compared to areas where beaver activity was absent. Accordingly, Puttock *et al.* (2017) also found beaver ponds to be more acidic than ponds without beavers. All British amphibians prefer a neutral pH of 6-9 (Beebee, 1983). However, water pH was not found to significantly predict adult amphibian abundance, although adult amphibian abundance decreased as the pH increased and became more alkaline. It is likely that if the beavers become active in the areas where they are currently absent, they will make the water more acidic and closer to neutral, benefitting amphibians. However, in some cases, beaver activity has been found to make the water more alkaline, with the effects of beaver activity on water pH seemingly site-dependent (Margolis *et al.*, 2001). To investigate the relationship further and the impact on amphibians, it is essential that water pH is recorded within the beaver enclosure as part of the monitoring plan, especially due to the uniqueness of the study site.

Contrasting with the other environmental variables, increasing water depth was shown to be significantly positively related to adult amphibian abundance. Water depth was also significantly different in areas where beaver activity was present and absent, with beaver activity areas shown to have higher water depth. Other studies have demonstrated that beavers increase water depth through damming creating new wetlands and ponds (Gollmann *et al.*, 2002; Swinnen *et al.*, 2019). However, literature reporting that beavers increase water depth usually refers to lotic environments where the beavers make the habitat lentic (Hood & Larson, 2015). As the IVNR is already a lentic environment with the water source primarily being groundwater, beaver activity will most likely have limited impact on water depth, with only minor fluctuations caused through the increase or decrease of areas of underwater vegetation. Therefore, the results from this investigation would suggest that beavers and amphibians have similar habitat selection preferences in terms of pond shore depth within the IVNR, with both selecting deeper water edges.

Significantly more adult amphibians were also encountered at night. This is to be expected, as adult common frogs, common toads, and smooth newts are more active at night (Vences *et al.*, 2000). However, day surveys should continue within the IVNR Nottinghamshire Wildlife Trust (NWT) amphibian monitoring plan, as young amphibian detection rates were notably higher during daylight. The continuation of both day and night visual encounter surveys is supported by Sewell *et al.* (2010), with their investigation also finding that alternative surveying times allow multiple amphibian life-stages to be recorded.

There was a significant association between young amphibian abundance and beaver activity, with areas where beaver activity was present shown to have the highest frequency of 25+ young amphibians encountered per visit. A high level of young amphibian recruitment has been linked to beaver-modified habitats due to increased levels of CWD leading to high nutrient content (Brönmark & Hansson, 2017; Stevens *et al.*, 2007). Total dissolved solids (TDS) are the metric usually used to measure nutrient content (Boyd, 2020). There was a significant difference in TDS between areas where beaver activity was present and areas where beaver activity was absent, with beaver-active areas having a higher TDS content. Higher levels of CWD have also been shown to increase protection for tadpoles and young amphibians due to a greater number of hiding places (Janiszewski *et al.*, 2014). Therefore, the higher TDS content caused by beaver activity could explain why beaver-active areas had higher young amphibian abundance than areas where beaver activity was absent.

Due to the uniqueness of this investigation, both in terms of timescale and study site, the findings should be interpreted with caution. The slight variation in time of year and use of different surveyors must be considered when comparing this investigation with that of Woods (2021). Furthermore, the difference in environmental variables between areas where beaver activity was present and areas where beaver activity was absent

could be due to habitat characteristics that were there before the beavers were reintroduced and not due to beaver activity. However, this short-term investigation is part of a wider project in which amphibian abundance and diversity within the study site will be monitored for many years, which will diminish these limitations. The future monitoring plan should continue to use the same methodology as this investigation along with other amphibian sampling techniques. Sewell *et al*. (2010) found that adding bottle-trapping to their amphibian surveys led to greater detection of all three British newt species. With only two smooth newts sampled by this investigation using visual encounter surveys, the ongoing monitoring programme should include bottle trapping to effectively monitor the newt population. Moreover, beaver projects at lotic sites within the U.K. have found a dramatic increase in egg spawn counts each year from when the beavers were reintroduced (Brazier *et al*., 2020). Therefore, egg counting should also be included as standard in the monitoring plan with surveys starting earlier in the year.

CONCLUSION

With amphibians declining across the U.K., there is a need for alternative management strategies to counteract population declines. As ecosystem engineers, beaver reintroduction has been shown not just to benefit beaver conservation but also other species, including amphibians. Therefore, the Idle Valley Nature Reserve offers a unique opportunity to investigate the relationship between amphibians and beaver activity within a lentic habitat, allowing further understanding of beavers as management tools. The intention of this study was to investigate the short-term impact of beavers on amphibian abundance and diversity post-reintroduction, and to pave the way for the future amphibian monitoring programme within the Idle Valley Nature Reserve. This investigation demonstrated that the reintroduction of beavers has not had a negative short-term impact on adult amphibians, and may have positively impacted recruitment levels, with significantly higher abundance of juvenile amphibians observed in beaver-active areas. The results suggest that over time the beavers will have a wider positive impact on amphibian diversity and abundance as seen in other beaver trials. Therefore, continuation of the monitoring programme is essential and will most likely provide further evidence for the support of beaver reintroductions and help amphibian conservation.

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Distribution of non-native terrestrial and freshwater amphibians and reptiles in Scotland

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ABSTRACT

Surveillance of non-native species is important for biosecurity and ecological reasons. This paper presents a baseline of the distribution of non-native terrestrial and freshwater amphibian and reptile species in Scotland. Multiple datasets were used to confirm which non-native terrestrial and freshwater species of amphibians and reptiles are currently present in Scotland, and map their known distribution. Citizen Science records were found to be extremely useful when photographs were included. Four non-native terrestrial and freshwater amphibian and reptile species were found to be present in Scotland, including Alpine newt (*Ichthyosaura alpestris*), sand lizard (*Lacerta agilis*), Chinese pond turtle (*Mauremys reevesii*), and common slider (*Trachemys scripta*).

INTRODUCTION

Although there have been studies focused on distribution of particular non-native species in the U.K. (notably non-native turtles and Alpine newt *Ichthyosaura alpestris*), little has been published regarding the distributions of non-native amphibians and reptiles in Scotland (McInerny & Minting, 2016; Allain, 2019; Allain & Lynn, 2021). Non-native species can disrupt native ecology and may be carriers of diseases novel to native species (Kraus, 2015). For example, the spread of chytrid fungi (*Batrachochytrium dendrobatidis* (Bd) and *B. salamandrivorans* (Bsal)) is linked to introduced species, and these pathogens are causing global amphibian extinctions through the disease they can cause – chytridiomycosis. In a Scottish context, Alpine newt can be an asymptomatic or "silent" vector for these fungi (Cunningham & Minting, 2008; Wilkinson *et al.*, 2010; Smith, 2014; Cunningham *et al.*, 2019).

Under the Wildlife and Countryside Act 1981 (as amended in Scotland by the Wildlife and Natural Environment (Scotland) Act 2012), it is illegal to release an animal to a location outside its native range, allow an animal to escape from captivity to a location outside its native range, or otherwise cause an animal not in the control of any person to be at a location outside its native range.

By collating existing records, this paper presents a baseline of the distribution of non-native terrestrial and freshwater amphibian and reptile species in Scotland, providing a basis for decision making and future surveillance.

METHODS

Existing records of non-native terrestrial and freshwater amphibian and reptile species in Scotland were collated from a range of data sources, as summarised in Table 1. For this study, terrestrial and freshwater species considered native were defined using McInerny & Minting (2016) and included common frog (*Rana temporaria*), common toad (*Bufo bufo*), natterjack toad (*Epidalea calamita*), great crested newt (*Triturus cristatus*), palmate newt (*Lissotriton helveticus*), smooth newt (*Lissotriton vulgaris*), common lizard (*Zootoca vivipara*), slow-worm (*Anguis fragilis*), and adder (*Vipera berus*).

Furthermore, barred grass snake (*Natrix helvetica*) has not been included as a non-native reptile, as its status in Scotland remains unclear, with evidence suggesting it is a native species which has been present and possibly breeding in the south of the country for a century or more (Cathrine, 2014, 2016). Additional research is required to confirm if barred grass snake is native or non-native.

Any other species of amphibian and reptile were considered non-native, although species unable to persist in the wild in Scotland due to climatic conditions were not included. Collated data were plotted in ArcGIS Pro, and thoroughly verified. Verification involved checking provenance/recorder, grid references, notes, descriptions, and habitat, as well as photographs where available.

RESULTS

A total of 101 records of non-native terrestrial and freshwater amphibian and reptiles was collated, distributed over 19 10 km squares, and representing four species: Alpine newt, sand lizard, Chinese pond turtle, and common slider. Table 2 summarises the results, and distribution maps are provided for each non-native amphibian and reptile species identified in Fig. 1.

Alpine newt

Alpine newt is the most frequently recorded of the four non-native species present in Scotland, with 62 records. Its distribution appears to be disjunct, with four apparently geographically distinct populations:

Data holder	Data access method	Licence*
Amphibian and Reptile Conservation Trust	NBN Atlas	CC BY, CC BY-NC
Amphibian and Reptile Groups of the UK	NBN Atlas, Record Pool	CC BY-NC
Central Scotland Amphibian and Reptile Group	Record Pool	CC BY-NC
Caledonian Conservation Ltd	Direct	CC BY-SA
Clyde Amphibian and Reptile Group	Record Pool	CC BY-NC
Froglife	NBN Atlas	CC BY-NC
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Scotland's Environment Web and Biological Records Centre	NBN Atlas	OGL
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Table 1. Details of data sources used to collate non-native amphibian and reptile records in Scotland (including the method by which data were accessed, and the licence under which use is granted for this non-commercial research).

OS National Grid 10 km square	Species			
	Alpine newt (*Ichthyosaura alpestris*)	**Sand lizard** (*Lacerta agilis*)	**Chinese pond turtle** (*Mauremys reevesii*)	**Common slider** (*Trachemys scripta*)
NM15		1		
NN71				1
NO00	2			
NO21				2
NO32				1
NO52				1
NO55				2
NS28	1			
NS47				3
NS56			1	16
NS66				6
NS67				1
NS76	2			
NS79				2
NT16	1			
NT17	18			
NT26	1			
NT27	37			2
NX76				5
Total records	**62**	**1**	**1**	**42**
Total 10 km squares	**7**	**1**	**1**	**12**

Table 2. Summary of collated non-native amphibian and reptile records, including where they were located (OS National Grid 10 km square), total records, and total OS National Grid 10 km squares each species has been recorded from.

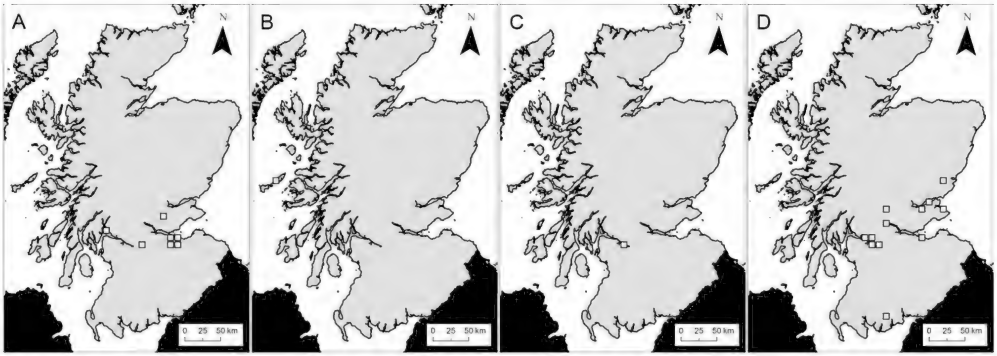

Fig. 1. Maps showing distribution of non-native amphibian and reptile species in Scotland. (A) Alpine newt (*Ichthyosaura alpestris*) (B) sand lizard (*Lacerta agilis*). (C) Chinese pond turtle (*Mauremys reevesii*). (D) Common slider (*Trachemys scripta*). White squares indicate occurrence at OS National Grid 10 km resolution. Data sources: Esri, Maxar, Earthstar Geographics, the GIS user community, and the data holders detailed in Table 1.

Edinburgh (City of Edinburgh), Dollar (Clackmannanshire), Glenboig (North Lanarkshire), and Helensburgh (Argyll & Bute). Although found in seven OS National Grid 10 km squares, the majority of records (50) are from just two: NT16 and NT26. This reflects the large number of records from Edinburgh and its surroundings (Fig. 2). Records dated from 1987 to 2023.

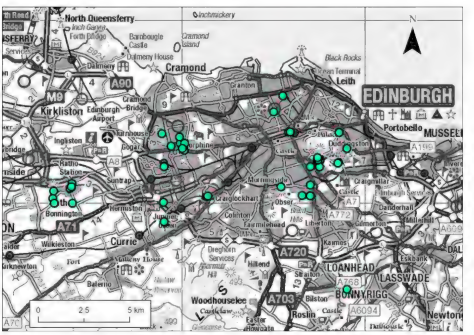

Fig. 2. Map showing distribution of Alpine newt (*Ichthyosaura alpestris*) in Edinburgh and the surrounding area at highest resolution possible (coloured dots indicate record locations). Data sources: Esri, Maxar, Earthstar Geographics, the GIS User Community, and the data holders detailed in Table 1. Contains Ordnance Survey data © Crown copyright and database right 2023.

Sand lizard

The only verified record of a population of sand lizard in Scotland is from the island of Coll, dating from 1970.

Chinese pond turtle

There is only a single record of one Chinese pond turtle in Scotland, from Glasgow Botanic Gardens in 2022.

Common slider

Common slider is the most widely distributed non-native amphibian or reptile species in Scotland, recorded from 12 OS National Grid 10 km squares. It is also the second most frequently recorded non-native species, with 42 records. There are 10 distinct population centres: five urban and five rural. The majority of records (25) are from Glasgow and Clydebank (Fig. 3). Record dates ranged from 1993 to 2022. There are three recognised sub-species of common slider: red-eared slider (*T. scripta elegans*), yellow-bellied slider (*T. scripta scripta*), and Cumberland slider (*T. scripta troostii*) (Seidel & Ernst, 2006). Of these red-eared and yellow-bellied slider have definitely been recorded in Scotland. However, many records are at species level only, and so it is not possible to determine abundance of either of these recorded sub-species, or confirm presence or likely absence of the as yet unrecorded Cumberland slider.

Fig. 3. Map showing distribution of common slider (*Trachemys scripta*) in Glasgow and the surrounding area at highest resolution possible (coloured dots indicate record locations). Data sources: Esri, Maxar, Earthstar Geographics, the GIS User Community, and the data holders detailed in Table 1. Contains Ordnance Survey data © Crown copyright and database right 2023.

DISCUSSION

Alpine newt

Until 2016, Alpine newts were only recorded from Edinburgh, Ratho, and Helensburgh. These were considered to represent isolated populations unable to

disperse due to the urban environment, despite the species being found progressively further from Ratho in railway embankments during maintenance works, and the close proximity of this population to the Union Canal in which all three native newt species have been recorded as breeding (Wilkinson *et al.*, 2010; McInerny & Minting, 2016; Robbemont *et al.*, 2023; Caledonian Conservation Ltd., 2024). It has been assumed that the Edinburgh populations relate to a single origin associated with a university, and that the Helensburgh population is a separate occurrence relating to private garden ponds (Peter Leach, pers. comm.; Irving, 1987; Ball *et al.*, 2023). However, in 2016, another population was reported from Glenboig, 40 km west of the Ratho population, and 45 km east south-east of the Helensburgh records, and included in the distribution map published in McInerny & Minting (2016). The Glenboig population is not included in the most recent publication regarding the distribution of Alpine newt in the U.K. (Allain & Lynn, 2021), as the records were not contained within the datasets used in that study (Steven Allain, pers. comm.). Furthermore, a fourth population centre was confirmed near Dollar, Clackmannanshire in 2021, located 30 km north north-west of the Ratho records, and on the other side of the Firth of Forth.

Due to the geographical barriers to dispersal and distances involved, it seems likely that the four main population centres for Alpine newt in Scotland relate to separate introduction events. However, there is evidence of dispersal, particularly in the Edinburgh area. Furthermore, Alpine newts have been found to hibernate in embankments within 1 m of the Union Canal at Ratho, and it is likely that this will become a vector for dispersal throughout the central belt, if it is not already.

The findings regarding the distribution of Alpine newts in Edinburgh and the wider area are of particular interest. It has been believed that there are three populations of Alpine newts in Edinburgh: Duddingston, Mortonhall Golf Course, and Ratho (Ball *et al.*, 2023). These have been widely considered to be isolated and unable to disperse due to the surrounding urban environment (Peter Leach, pers. comm.; McInerny & Minting, 2016; Ball *et al.*, 2023). It is also commonly assumed that all of these populations originated from released overstock of Alpine newts at a local university between the 1950s and 1970s, before release of (most) non-native species became illegal in Scotland (McInerny & Minting, 2016; Ball *et al.*, 2023). However, a recent mitochondrial DNA study that sampled Alpine newt throughout the U.K. included the Duddingston, Mortonhall Golf Course, and Ratho populations and found that the latter was genetically distinct from the first two (Ball *et al.*, 2023). This is unsurprising, as the Duddingston and Mortonhall Golf Course populations are both close to the local university which is believed to be the origin, while Ratho is over 10 km west. Furthermore, the origin of the Ratho Alpine newt population is known and more recent, having been introduced in the 1990s in an attempt to prevent a local development (Peter Leach, pers. comm.). The newts were mistakenly believed to be great crested newts, a European Protected Species under the European Union (EU) Habitats Directive (Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora).

The concept of three distinct populations of Alpine newts within Edinburgh, unable to disperse through the urban environment, appears to be incorrect based on the results of this study. Alpine newts were found to be widespread throughout Edinburgh and the wider area (Fig. 2 and Table 2). Whether this relates to dispersal or multiple introductions is unclear. It should be noted Alpine newts were also known to be present in a pond at Corstorphine Hill (between Duddingston/Mortonhall Golf Course and Ratho) in the 1990s, and a local garden centre sold this species of newt until the 2020 COVID-19 pandemic lockdown.

The previous view of Alpine newts having a limited distribution at three or four population centres, unable to disperse, with one estimate of occurrence being in as few as ten ponds (McInerny & Minting, 2016), is no longer accurate, and this species is more widely distributed throughout central Scotland. Alpine newts are able to breed in Scotland – mating and all life-stages have been recorded (McInerny & Minting, 2016) – and so range expansion is likely if there are no barriers to dispersal.

Alpine newts are native to many regions of Europe, but not to any part of the U.K. They are widespread throughout Europe, although have been introduced to some locations (Robbemont *et al.*, 2023). Although the Duddingston and Ratho populations were found to be genetically distinct, they were also found to have originated from the same broad population (Ball *et al.*, 2023; Robbemont *et al.*, 2023).

Sand lizard

Sand lizards were introduced to the island of Coll in 1970 and 1971, before the release of (most) non-native species became illegal in Scotland (McInerny & Minting, 2016). Thirty-seven individuals were collected from a development site in Dorset and released in suitable habitat at Crossapol to safeguard these individuals and to investigate the climatic tolerance of the species (Langton & Beckett, 1995; Bowler & Hunter, 2007; McInerny & Minting, 2016). The population has remained stable, possibly increasing slightly, and does not appear to have dispersed to other locations on the island (McInerny & Minting, 2016). It is worth noting that Coll has relatively limited suitable habitat for this species compared with the neighbouring island of Tiree. The sand lizard is native to much of Europe, including England and Wales, and is a European Protected Species within its native range. This species is relatively frequently recorded in Scotland by the public using Citizen Science platforms. However, other than those located on Coll, records have been found to relate to green common lizard morphs based on photographs, habitat, or communication with the recorder.

Chinese pond turtle

A single Chinese pond turtle specimen was recorded at Glasgow Botanic Gardens in 2022, the first reported record for the U.K. (Cathrine & Monir, 2022). The Chinese pond turtle is a species of terrapin found in China, Taiwan, the Korean Peninsula (excluding Jeju Island), and Japan, although recent genetic studies indicate it is likely to have been artificially introduced to the latter country (Suzuki *et al.*, 2011; Oh *et al.*, 2017; Rhodin e*t al.*, 2021). This species has recently been found in the Republic of Ireland (Rob Gandola, pers. comm.).

It is unlikely that *M. reevesii* would establish functional populations in Scotland, as the climate is even less suitable for this species than for *T. scripta* (see below), but individuals may persist outdoors for a considerable period, as this terrapin species is known to live for over 20 years (Kopecky *et al.,* 2013; Myhrvold *et al.*, 2015).

Common slider

The common slider is the most widely distributed non-native species found in this study. The distribution was found to be largely consistent with that reported in Allain (2019), the most recent U.K. publication for this species. However, the common slider was found to be more widely distributed than previously thought, with this study confirming presence in Dumfries & Galloway and Perthshire.

While Glasgow and Clydebank appear to be the hotspots for the common slider in Scotland (Fig. 3 and Table 2), it has been recorded from many different locations, with ten broad geographic centres. While non-native species are often considered to be an urban issue, this does not appear to be true of common sliders in Scotland, as half of the centres are rural. However, many of these rural locations are wildlife reserves, country parks, or close to wildlife parks with exotic specimens. The only exception to this is the record from Dumfries & Galloway, which is genuinely remote from public attractions and human settlements.

The common slider originates from south-eastern and central U.S.A. and northern Mexico, is highly invasive, and now occurs in many other countries, including within Europe (Seidel & Ernst, 2006; Kopecky *et al.*, 2013). It can cause significant negative impacts on native ecology, and is included in the IUCN list of the 100 most invasive species (Lowe *et al.*, 2000). Although breeding attempts have been confirmed in Scotland, the climate is unsuitable for egg development, meaning populations are limited by individual lifespans, although this species can live for over 20 years, and as long as 40 years in exceptional cases (Beebee & Griffiths, 2000; Cathrine & Monir, 2022). They can therefore persist for a long time in a waterbody depending on age at release or escape (Wareham, 2008; Myhrvold *et al.*, 2015; McInerny & Minting, 2016; Allain, 2019). For example, the author is aware of an individual red-eared slider that has been present in a rural pond in Scotland for 20 years.

Common sliders are popular pets, and sales first peaked when the "Teenage Mutant Hero Turtles" (known as "Teenage Mutant Ninja Turtles" in other countries) animated series debuted in the U.K. in 1989 (Beebee & Griffiths, 2000; Allain, 2019). Young *T. scripta* would be purchased for children, with parents not realising how quickly and how large they grow. After outgrowing enclosures, these unwanted pets would be released into larger waterbodies. Some specimens observed by the author have shown signs of restricted carapace growth caused by being kept in an inappropriately small enclosure for some time. Sales of common sliders continue to be linked with the popularity of the "Teenage Mutant Ninja Turtles" franchise.

The most commonly encountered sub-species in the U.K. is the red-eared slider, which is unsurprising as this is the most attractively marked of the three, with striking red lines on the head. The second most commonly encountered sub-species is the yellow-bellied slider, while the least frequently recorded is the Cumberland slider which is also the dullest marked sub-species (Allain, 2019; Cathrine & Monir, 2022).

CONCLUSIONS

Scotland's climate is unsuitable for many non-native terrestrial and freshwater amphibians and reptiles. However, there are at least four species which persist in the wild, including two which are successfully breeding - Alpine newt and sand lizard. It is possible that climate change may result in conditions becoming suitable for Chinese pond turtle and common slider egg development, and for other non-native amphibian and reptile species to become established.

Non-native species can have a negative impact on native biodiversity. Notably, the spread of disease is a serious risk, and Alpine newts are known to be asymptomatic carriers of chytrid fungi which can cause mortality and even extinction in other species (Cunningham & Minting, 2008; Wilkinson *et al.*, 2010). Although no chytrid has been identified from Alpine newt populations in Scotland, sampling has been based on the generally assumed limited distribution (Cunningham & Minting, 2008; Smith, 2014; Cunningham *et al.*, 2019). This study has shown that Alpine newts are far more widespread in Scotland than previously assumed.

Non-native species can also be disruptive to local ecology (Kraus, 2015). Notably, *T. scripta* is one of the 100 most invasive species in the world and can cause declines in native species through predation and competition (Lowe *et al.*, 2000; Kopecky *et al.*, 2013; Cathrine & Monir, 2022).

Records of non-native terrestrial and freshwater amphibians and reptiles in Scotland are predominantly from heavily populated urban areas. There are two possible reasons for this. Non-native species are more likely to be introduced where there are higher densities of humans or wildlife records are more likely to be seen and reported via Citizen Science platforms from areas with higher densities of humans. It is likely that both of these factors are influencing the known distribution of

non-native terrestrial and freshwater amphibians and reptiles in Scotland. It is important that future surveillance of non-native terrestrial and freshwater amphibians and reptiles includes rural areas. Targeted surveys for Alpine newts along the Union Canal are particularly critical for understanding the distribution of this species.

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Greater Glasgow pond amphibian surveys 2022

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ABSTRACT

In 2019, Clyde Amphibian and Reptile Group (CARG) decided to organise a spring 2020 common frogspawn (*Rana temporaria*) survey of the Greater Glasgow area, Scotland. The COVID-19 lockdown postponed this project until 2022. The 2022 survey area was spread across four council districts: Glasgow City, South Lanarkshire, Renfrewshire and East Renfrewshire. The primary aim of the surveys was to collect records of amphibian breeding throughout the Greater Glasgow Area, with secondary aims of: (1) revisiting the ponds to see if the ponds supported the spawn through to tadpole and froglet stages; (2) assessing the condition of the ponds for amphibians; (3) identifying areas for habitat enhancement work; and (4) collecting data on breeding common toads (*Bufo bufo*) and newts (*Lissotriton, Ichthyosaura* and *Triturus* spp.). A total of 45 volunteers participated in the surveys. Surveys were completed between March and May 2022, with a primary focus between March and April in order to capture frog spawning data. Surveyors were asked to record amphibian population data, and habitat data in order to estimate Habitat Suitability Indices. In total 162 ponds were surveyed, with evidence of breeding common frogs found in 66.1% of ponds with 11,478 frogspawn clumps counted on the first set of surveys. Only 12.2% of ponds were found to contain common toads, and small newts (*Lissotriton* spp.) were identified in only 7.4% of ponds. In relation to the quality of breeding habitat, 24.5% of ponds were assessed as drying out annually, which significantly reduces the suitability of these ponds for breeding. This figure is predicted to increase with anthropogenic climate change reducing the number of breeding ponds available to amphibians in the absence of intervention. Furthermore, the majority of the ponds surveyed were assessed as offering poor or below average suitability for great crested newts (*Triturus cristatus*) and nearly half of the ponds surveyed were found to have poor or bad water quality, which can increase stress levels for larval amphibians and may adversely affect mortality levels. However, as the analysis of water quality was subjective, these findings should be treated with caution.

INTRODUCTION

The common frog (*Rana temporaria*) is a common and widespread pool-breeding amphibian found throughout mainland Scotland and many of the islands (McInerny & Minting, 2016). It is regarded as the commonest amphibian in the U.K. (Wilkinson & Arnell, 2013).

In 2019, the Clyde Amphibian and Reptile Group (CARG) organised a spring 2020 frogspawn survey of the Greater Glasgow area. The context for this was that a collaboration between Froglife and Glasgow City Council (2008-13) had led to the creation and/or restoration of 55 ponds on Council land across the city. Some limited assessment of these ponds had been carried out in the intervening years, but no comprehensive survey. The City Council was enthusiastic about CARG's plan. A grant to pay expenses was obtained from Glasgow Natural History Society's Blodwen Lloyd Binns Bequest. The primary aims of the survey were to collect frogspawn records across the Greater Glasgow area, and to provide records for the Glasgow Museums Biological Records Centre (GMBRC). In addition, surveyors were to be asked to collect records of any other amphibian or reptile species that they found in the ponds, including smooth newts (*Lissotriton vulgaris*), palmate newts (*Lissotriton helveticus*), great crested newts (GCN) (*Triturus cristatus*), Alpine newts (*Ichthyosaura alpestris*) and common toads (*Bufo bufo*). A field training course for volunteers was organised for March 2020. However, the COVID-19 pandemic and lockdown intervened. By late 2021, it seemed possible that surveys were safe again. By then, we had learned the ease and usefulness of online training, and we again set about recruiting and training volunteers.

The 2022 survey area included 162 ponds across four council districts: Glasgow City, South Lanarkshire, Renfrewshire and East Renfrewshire. Details of all the pond locations can be found in the Appendix.

The secondary aims of the survey were to:
(1) Revisit the ponds after the initial survey, to determine if the ponds supported the spawn through to tadpole and froglet stages.
(2) Assess the condition of the ponds for amphibians.
(3) Identify areas for habitat enhancement work.
(4) Collect data on breeding common toads and newt species.

METHODS

Training

A total of 45 volunteers participated in the surveys. Surveyors were recruited through online information about the survey distributed to CARG members, Froglife, GNHS members and biological science students at the University of Glasgow. All surveyors were required to join CARG in order to be covered by ARG-UK insurance. Surveyors were provided with the following training:

(1) Two online training sessions using the platform Zoom were held on 20th February and 27th February 2022, which covered amphibian identification, ecology, and the survey techniques that would be implemented (detailed further in Survey Techniques).

(2) A daytime training session was held at Queens Park, Glasgow on 19th March 2022, which provided surveyors with the opportunity to practice the survey techniques, and measurements, in a safe environment.

(3) A night-time training session was held in late March 2022, on amphibian identification through torch surveying: this was held in Calder Glen Country Park, East Kilbride.

Volunteers were provided with the following equipment, when requested: a net for sampling aquatic invertebrates, a copy of OPAL's Freshwater Invertebrate Identification Guide (OPAL, 2015), and an amphibian identification guide. CARG's set of Clulite torches were also made available to any volunteers who wished to complete night-time torch surveys.

Survey techniques

Surveys were completed between March and May 2022, with a primary focus between March and April in order to capture frog spawning data. Surveyors were asked to record amphibian population data, and habitat data when visiting the ponds. For health and safety reasons surveyors were assigned to work in pairs or small groups. Survey pairs/groups were assigned ponds based on their location and transport access. They were encouraged to survey additional ponds where they wished to do so.

Amphibian population data

Surveyors were requested to collect the data outlined in Table 1 during their visits, from bankside visual inspections. Surveyors were instructed not to search for newt eggs due to the destructive nature of searching. Netting for amphibians was discouraged in order to reduce the risk of inadvertent offences being committed by volunteers through disturbance of GCN in ponds.

Habitat data

The survey methodology focused on the collection of data in order to undertake a Habitat Suitability Index (HSI) for each of the ponds visited. The gathering of these data included a mixture of volunteer data collection and desk-based analysis. The breakdown of these elements is detailed in Table 2. The subsequent HSIs were calculated using standard guidance (Oldham *et al.*, 2000) with geographic locations determined based on recent Scottish research (O'Brien *et al.*, 2017). In addition, surveyors were asked to provide any other notes in relation to the pond, its condition, or its surroundings, that they deemed to be relevant to its suitability for amphibians.

Data management

Entry

Volunteers submitted data forms and photographs to CARG. The survey data were then entered into a master Excel spreadsheet. Where data provided by surveyors did not directly correlate with an input for calculating SI values, on a precautionary basis the data were translated to a value which would have a less negative impact on the HSI calculation.

Analysis

HSIs were calculated using formulae input into the master excel spreadsheet using the standard equation

Species	No. of adults	No. of young	Tadpoles & efts (Present or Absent)	No. of spawn clumps/strings	Spawn matt size (m^2)	No. of dead
Common toad (*Rana temporaria*)					N/A	
Common frog (*Bufo bufo*)						
Small newt (unidentified) (*Lissotriton* spp.)				N/A	N/A	
Palmate newt (*Lissotriton helveticus)*				N/A	N/A	
Smooth newt (*Lissotriton vulgaris*)				N/A	N/A	
Great crested newt (*Triturus cristatus*)				N/A	N/A	
Alpine newt (*Ichthyosaura alpestris*)				N/A	N/A	
Others amphibian/ reptile species						

Table 1. Amphibian survey data to be collected.

SI no.	Data type	Description	Collection/determination method
1	Geographic location	The pond's location in relation to the likely presence of GCN (O'Brien et al, 2017) as offering either marginal or unsuitable habitat for GCN.	Ponds were mapped in QGIS over a digitized map detailing the boundaries for the Geographic Location boundaries.
2	Pond area	The size of the pond in m^2.	Pond area estimated by surveyors.
3	Pond permanence	An approximation of the number of years in 10 the pond dries up.	Estimated based on pond conditions and where possible through discussion with local landowners/managers/residents.
4	Water quality	An interpretation of the quality of the water based on invertebrate diversity, presence of plants, and understanding of water sources.	Water quality determined by surveyors; where possible (and safe to do so) sampling water via netting to establish an understanding of the invertebrate species present.
5	Shade	Percentage of pond perimeter shaded to at least 1m from the shore.	Estimated by surveyors.
6	Waterfowl effect	An interpretation of the impact of waterfowl on the pond.	Determined by surveyors.
7	Fish presence	An interpretation of the likely fish presence in the pond.	Determined by surveyors.
8	Pond density	Number of ponds within 1km of the pond.	Pond density calculated using MagicMap (DEFRA, 2022)
9	Terrestrial habitat connectivity	Assessment of the suitability of habitat within 500 m of the pond in providing terrestrial commuting and foraging habitat for amphibians.	Determined by surveyors.
10	Macrophyte cover	Percentage of pond covered by macrophyte vegetation.	Coverage estimated by surveyors.

Table 2. Data for Habitat Suitability Index (HSI) completion.

(Oldham *et al*., 2000), and frogspawn mat sizes were converted to number of spawn clumps (Griffiths *et al*., 1996). Data were reviewed for correlations through Excel, and then potential correlations were tested for significance using univariate analysis in SPSS. Survey data for frog tadpoles, newt efts and newt eggs were analysed in relation to their presence/absence; otherwise, data were analysed using the recorded abundances.

Limitations

As the surveys were predominantly bankside visual surveys throughout March and April, it is considered probable that newt presence has been under-recorded, as these are often best detected through night-time torch surveys, or through netting. In addition, common toads breed later in the year than frogs, and as only a small number of night-time surveys were completed, the number of ponds used by breeding common toads is anticipated to have been under-recorded.

Grid references were not collected for all ponds, and whilst this may make it more difficult to revisit some ponds, the general area of the ponds is known so it has not impacted on the ability to complete the HSIs.

Surveyors did not always complete all aspects of the form, so the volume of data collected differed across criteria. However, for the majority of ponds, information on all factors was recorded, and as such it is considered there is still a sufficient dataset to interpret trends.

RESULTS

Amphibian population results

Evidence of breeding common frogs was found in 99 ponds (61.1% of ponds surveyed). A breakdown of how this is split across the visits can be found in **Error! R eference source not found.** Only 20 ponds were found to contain common toads (12.2% of total), in which four were identified as having toad spawn, and five where toads were identified through the presence of toad corpses adjacent to the ponds. Small newts were identified in a mere 12 ponds (7.4% of total), as adult palmate newts, unidentified small newts or newt efts, and in one instance, newt eggs.

Habitat Data

Habitat suitability indices

Insufficient data were gathered to calculate HSIs for 11 of the surveyed ponds: notes provided by surveyors indicate that six of these ponds were dried out at the time of survey.

The HSI results band ponds based on their perceived suitability for GCN as offering between "Poor" and "Excellent" suitability. The banding of the surveyed

ponds, for which sufficient data were collected is detailed in Table 4. Where a pond obtained different HSI scores across different visits, on a precautionary basis the worse of the two HSI scores has been used.

Drying out frequency
The approximate drying out frequency of the 151 assessed ponds is detailed in Table 5.
Water quality
The water quality was recorded for 151 of the surveyed ponds and is described in Table 6.

Environmental factors vs. observed amphibian presence
Univariate analysis that identified links between environmental variables and observed amphibian presence is summarised in Table 7.

	Visit 1	Visit 2	Visit 3
No. of ponds visited	162	29	2
No. of clumps of spawn	11,478	452	0
No. of ponds with clumps of spawn	97	7	0
No. of ponds with tadpoles	23	1	1
Mean no. clumps of spawn (visited ponds)	70.85	15.59	N/A
Mean no. clumps of spawn (only ponds with spawn)	118.33	64.57	N/A
No. of ponds showing evidence of breeding	98	8	1
% of visited ponds showing evidence of breeding	60.49%	27.59%	50%

Table 3. Evidence of breeding common frogs (*Rana temporaria*).

Suitability assessment	No. of ponds	Percentage of assessed ponds
Poor	67	44.4
Below Average	27	17.9
Average	25	16.6
Good	27	17.9
Excellent	5	3.3
Total	**151**	**100**

Table 4. Pond suitability for GCN.

Category	Drying out frequency	No. of ponds	Percentage of surveyed ponds
Never dries	Never dries	54	35.8
Rarely dries	Dries no more than two years in ten or only in drought	21	13.9
Sometimes dries	Dries between 3 years in ten to most years.	39	25.8
Dries annually	Annually	37	24.5
Total		**151**	**100**

Table 5. Drying out frequency of surveyed ponds.

Water quality	No. of ponds	Percentage of surveyed ponds
Bad	4	2.6
Poor	63	41.7
Moderate	54	35.8
Good	30	19.9
Total	**151**	**100**

Table 6. Water quality of surveyed ponds.

DISCUSSION

Frogs

Larger ponds were found less likely to have observable tadpoles than smaller ponds (P <0.05). This may be due to the reduced percentage of the large ponds being observable from the bank.

Ponds which did not regularly dry out were statistically found to be more likely to contain frogspawn (P <0.05), and also contained higher amounts of frogspawn. In addition, there was a possible but not statistically significant linkage (P <0.10) between the permanence of ponds and the number of adult frogs observed, with more adult frogs being observed in more permanent ponds.

Water quality was observed to have linkages with survey findings: however, a note of caution should be made here as the assessment of water quality was subjective, and made by a range of surveyors. There may be a linkage (P <0.10) between water quality and the number of spawn clumps identified in a pond, with

higher water quality ponds containing more spawn clumps (Fig. 1). It should be noted that this trend relates to observed spawn. It cannot be ruled out that higher amounts of spawn were in the polluted ponds pre-survey, and that this died at an early stage, resulting in a reduced amount of observable spawn. Ponds with better water quality were more likely (P <0.05) to have dead frogs observed at them. However, as only 12 ponds were found with dead frogs, this link should be treated with caution.

	Adults				Juveniles		Eggs			Dead	
HSI Category	**Common frog**	**Common toad**	**Small newt**	**Palmate newt**	**Common frog**	**Small newt**	**Common frog**	**Common toad**	**Small newt**	**Common frog**	**Common toad**
Geographic location											
Pond area					+						
Pond permanence	?	?	+				+				
Water quality			+	?			?		+	+	
Shade	?										
Waterfowl											
Fish					+					+	+
Pond density		?					?				
Terrestrial habitat							+				
Macrophyte cover				?							
Overall HSI			+					?			

Table 7. Summary table of univariate linear models: relationships between HSI categories and common frog (*Rana temporaria*), common toad (*Bufo bufo*) and newt (*Lissotriton* spp.) lifestages. Plus signs indicate statistically significant linkage (P <0.05), and question marks possible but not statistically significant linkages (P <0.10).

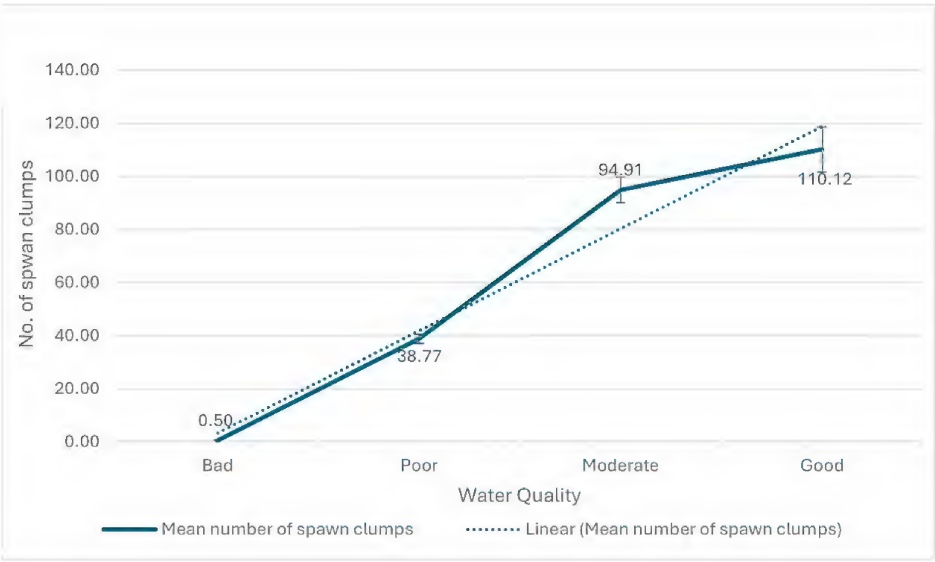

Fig. 1. Relationship between water quality and number of common frogspawn (*Rana temporaria*) clumps.

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There was a possible but not statistically significant positive correlation (P <0.10) between shade and number of adult frogs. Fewer dead frogs were observed

around ponds with higher fish populations (P <0.05), and tadpoles were more likely to be observed in ponds with smaller fish populations (P <0.05). There may be a link (P <0.10) between pond density and the amount of frogspawn present in a pond, with higher amounts of spawn found in ponds which were surrounded by greater number of ponds. As the quality of terrestrial habitat increased (P <0.05), the amount of spawn found in ponds increased. This is likely due to the habitats surrounding the pond being able to support a higher number of frogs in their terrestrial life stages. The data did not reveal a significant correlation between HSI category and number of spawn clumps (P >0.10) (Fig. 2). The existence of such a correlation is plausible as many of the factors that affect the suitability of a pond for GCN will also affect its suitability for common frog breeding, such as surrounding habitat types, proximity to other waterbodies, and the presence/absence of fish and waterfowl.

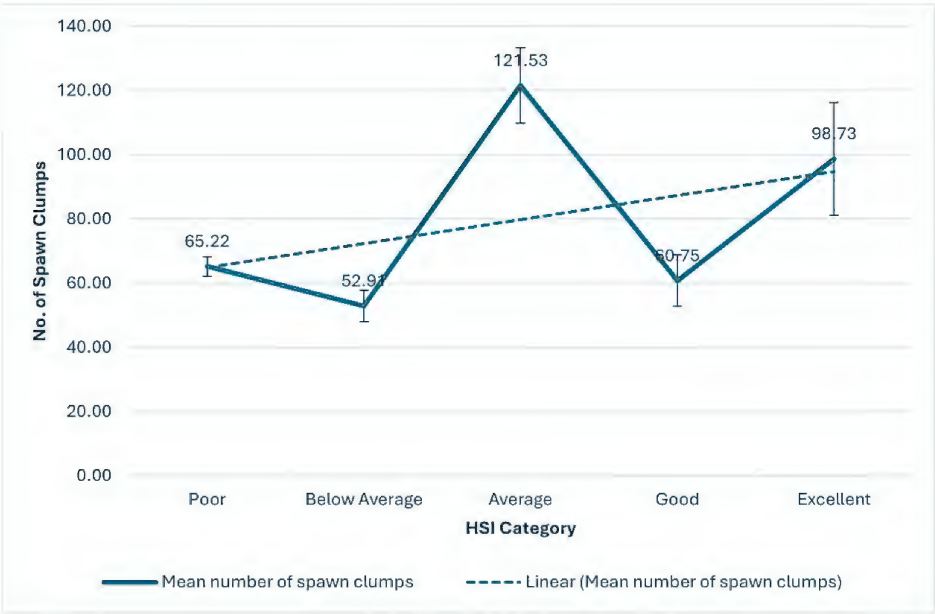

Fig. 2. Relationship between HSI Category and number of common frogspawn (*Rana temporaria*) clumps.

Insufficient temporal data were collected to draw meaningful conclusions, with only 25 ponds visited twice, and two visited three times. It is recommended in future years that an increased emphasis is placed upon surveyors completing monthly visits to ponds, in order to gain a further understanding of survival of the spawn progression into tadpoles and on to metamorphosis.

Common toads and newt species

As common toads were recorded at only 20 and newts at only 12 of the surveyed ponds, the sample sizes are too small to make any meaningful inferences, despite statistical linkages. We recommend that torchlight surveys are undertaken in future years throughout the amphibian breeding season. However, where this is not possible for health and safety reasons (for example due to the risk of antisocial behaviour), then daytime netting of ponds could be undertaken (Froglife, 2001). However, this will not be suitable for ponds containing aquatic invasive species such as New Zealand stonecrop (*Crassula helmsii*) and water fern (*Azolla filiculoides*), and surveyors would be required to be trained in their identification. Alternatively, eDNA analysis of ponds could be undertaken; if completed in May, this would be within the optimal period for capturing sloughed cells of all of the U.K.'s breeding amphibian species. However, this would require significant expenditure, and does not provide abundance data.

Habitats

The majority of the ponds surveyed (62.2%) were assessed as offering poor or below average suitability for GCN. Whilst this does not directly translate to any indices of habitat quality for other native amphibian species, all of the elements that are considered for GCN will also affect the suitability of ponds for other amphibian species, although there is now evidence to suggest additional abiotic factors need to be considered in assessing the suitability of ponds in Scotland for GCN (Harper *et al.*, 2019)

Nearly half of the ponds surveyed (44.4%) were found to have poor or bad water quality, which can increase stress levels for larval amphibians such as common frogs (Strong *et al.,* 2017), and may adversely affect mortality levels. However, as noted previously, the

analysis of water quality was subjective, so these data should be treated with caution.

Nearly a quarter of ponds were assessed as drying out annually (24.5%). This significantly reduces the suitability of these ponds for breeding. Whilst amphibians such as frogs may spawn in them, if the ponds dry out over the summer months, then juvenile amphibians will die before making it through metamorphosis to terrestrial life stages. A further 25.8% of ponds were assessed as sometimes drying out (between 3 years in 10 and most years). Whilst occasional drying out can benefit amphibian populations in ponds by leading to a reduction of predators, as the frequency of the ponds drying out increases, amphibian breeding success suffers. With the effects of anthropogenic climate change it is likely that without intervention the frequency of pond drying out will increase, and more ponds will dry out sometimes or annually, thus reducing amphibian recruitment.

CONCLUSION

The survey succeeded in its primary aim of collecting records of breeding amphibians around the greater Glasgow area. These data have been submitted to Clyde ARG and, following some tidying up, will be shared with GBMRC in early 2024. For future surveys, it is recommended that a recording form is used which more closely aligns with GMBRC's data entry form in order to streamline data submission.

The surveys succeeded somewhat in their goal of undertaking condition assessments for amphibians, with 151 ponds being condition assessed for GCN. It is acknowledged that this does not directly translate to an index of habitat quality for other native amphibian species, and that additional abiotic factors need to be considered in assessing the suitability of ponds in Scotland for GCN (Harper *et al.*, 2019). However, in the absence of an alternative rapid methodology, HSI does provide a rapid approximation which volunteers can easily learn to complete.

Only a small proportion of ponds was revisited, and therefore only limited data on the success of amphibian reproduction were gathered. In addition, only a small number of night-time surveys were undertaken identifying breeding newt species and common toads. This is considered likely due to a lack of capacity by the survey co-ordinators to continually liaise with surveyors throughout the survey season due to other commitments, and it is therefore recommended that if the survey is repeated in future years, dedicated resource is provided towards undertaking the surveys.

A review of the dataset indicates numerous ponds that have dried out and may be in need of habitat enhancement work. These data have not been reviewed in detail due to a lack of capacity, but will be made available in the complete, anonymised data set.

The surveys have provided a valuable glimpse into the health of the ponds around Glasgow. However, the condition of ponds can change considerably from year to year (Paterson, 2016). It is therefore recommended that the surveys are repeated in future years in order to gain a wider understanding as to the health of ponds within the Greater Glasgow area and their recruitment success for amphibians.

ACKNOWLEDGEMENTS

Thanks to all of CARG's volunteer surveyors for making the 2022 surveys happen, Erik Paterson for running the training session, and Glasgow Natural History Society (GNHS) for providing the funding to enable the surveys. Lastly, a thank you to Naomi Barron for her continued support and assistance.

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APPENDIX

[1]Pond names were assigned by volunteers. Occasionally for clarity, references have been added when sites are within Nature Reserves or Country Parks. Any gaps in numbering indicate a pond that was intended to be surveyed but for which no data were gathered.

[2]Due to calculations associated with assessing the number of clumps in a common frogspawn (*Rana temporaria*) matt (Griffiths *et al.*, 1996), where the total number of clumps records a partial clump (e.g. 78.27) the total number of clumps has been rounded down to the nearest whole number.

Pond name[1]	Nat. Grid Ref.	Max. no. frogspawn clumps counted[2]
Barshaw Park, Paisley - Large Pond	NS4996564265	0
Barshaw Park, Paisley - Small Pond	NS5004564265	292
Bingham's Pond	NS5540068300	45
Boylestone Quarry, Barrhead	NS4920559715	171
Brownside Farm	NS4854560855	2
Cardowan Moss 02	NS6563167218	0
Cardowan Moss 03	NS6504867376	83
Cardowan Moss 05	NS6543067194	116
Cardowan Moss 06	NS6597467149	0
Cardowan Moss 07	NS6600067149	0
Cardowan Moss 08	NS6606467071	97
Cardowan Moss 09	NS6589367089	0
Cardowan Moss 10	NS6588867073	0
Cardowan Moss 11	NS6550167475	0
Commonhead Moss 01	Not provided	80
Commonhead Moss 02	NS6970066000	117
Commonhead Moss 03	Not provided	75
Commonhead Moss 04	Not provided	89
Commonhead Moss 05	Not provided	38
Crossroads (Trig Point) Pond	NS4500060537	0
Darnley Country Park (CP)	NS5260358919	75
Darnley CP - Extra Pond 01	NS5269259003	0
Darnley CP - Extra Pond 02	NS5246058553	46
Dawsholm Park 01	NS5563069670	74
Dawsholm Park 02	NS5573069720	0
East Kilbride (EK) 03 - Calderglen CP Bottom Field	NS6547152886	149
EK04 – Calderglen CP Fire Pond	NS6541852863	4
EK05 – Calderglen CP Old Duck Pond (Lower)	NS6524252636	78
EK06 – Calderglen CP Old Duck Pond (Upper)	NS6523752630	113
EK07 – Calderglen CP Wildlife Pond	NS6551652660	18
EK08 – Calderglen CP Fred 's Pond	NS6584754715	59
EK09 - Glen Esk Marsh	NS6550054981	73
EK10 - Greenhills Road Substation	NS6422651942	0
EK11 - Hairmyres Woods	NS6053354486	22
EK13 - Langlands Amphibian Pond 01	NS6318551353	0
EK14 - Langlands Amphibian Pond 02	NS6321651379	0
EK18 - Redwood 01	NS6020154565	48
EK19 - Redwood 02	NS6027154595	5
East Kilbride (EK) Bonus 01	NS6412951090	62
EK Bonus 02	NS6411251088	18
EK Bonus 03	NS6410851076	25
EK Bonus 04	NS6404251136	60
EK Bonus 05	NS6408651253	17
EK Bonus 06	NS6426751954	41
EK Bonus 07	NS6344651738	19
Fereneze Golf Course Pond, Barrhead	NS4896059640	57
Glassford Bridge	NS7331345421	10
Glassford Pond	NS7311847051	149
Glen Moss Pool 03	NS3687269639	0
Glen Moss Pool 04	NS3690069650	1
Glen Moss Pool 05	NS3674169613	0
Glen Moss Pool 06	NS3700069880	0
Glen Moss Pool 07	NS3692069850	0

Pond name[1]	Nat. Grid Ref.	Max. no. frogspawn clumps counted[2]
Hamiltonhill Claypits LNR: Canal Basin	NS5836267499	0
Hamiltonhill Claypits LNR: Claypit Pond	NS5824867937	0
Harelaw Reservoir	NS4847059780	299
Harelaw Reservoir Pond	NS4865059580	146
Holmhills Wood LNR Long Pond	NS6400059610	227
Holmhills Wood LNR Main Pond	NS6391059650	126
Holmhills Wood LNR Square Pond	NS6394059700	81
Hurlet Hill 01	NS5157061461	43
Hurlet Hill 02	NS5155261481	75
Hurlet Hill 03	NS5143861523	132
Hurlet Hill 04	NS5142761513	85
Hurlet Hill 05	NS5141361500	289
Hurlet Hill 06	NS5140661555	0
Hurlet Hill 07	NS5158461458	1509
Hurlet Hill 08	NS5142461494	0
Hurlet Hill 09	NS5141261493	0
Jack's Pond, Brownside, Paisley	NS4854260863	38
Jenny's Well LNR A	NS4993062840	1
Jenny's Well LNR B	NS4990062820	4
Jenny's Well LNR C	NS4992062820	52
Jenny's Well LNR D	NS4991062830	1
Jenny's Well LNR E	NS4991062820	0
Langlands 01	NS6412951090	62
Langlands 02	NS6411251088	18
Langlands 03	NS6410851076	25
Langlands 04	NS6404251136	60
Langlands 05	NS6408651253	17
Langlands 06	NS6426751954	41
Langlands 07	NS6344651738	19
Langlands Industrial Estate	NS6412951090	62
Lethame Pond	NS6861044619	1711
Linwood Moss Puddle	NS4394065670	49
Lochwinnoch RSPB - LH Pond	NS3594058120	0
Lochwinnoch RSPB - Path end Puddle	NS3658058710	31
Lochwinnoch RSPB RH Pond	NS3505058000	0
Maxwell Park	NS5659462947	21
Muirshiel CP Ditch	NS3136863150	11
Muirshiel CP Lower	NS3126063140	0
Muirshiel CP Middle	NS3131563162	9
Muirshiel CP Upper	NS3126063210	92
Nether Lethame Duck Pond	NS6857344943	70
Newlands Park	NS5705960604	0
Pedmyre 01	NS5949057890	15
Pedmyre 02	NS5951057680	0
Pedmyre 03	NS5939057570	16
Pedmyre 04	NS5932057550	19
Pedmyre 05	NS5933057530	0
Pedmyre 06	NS5926057570	0
Pedmyre 07	NS5931057620	24
Pedmyre 08	NS5939057950	38
Pedmyre 09	NS5942057930	12
Pedmyre 10	NS5937057560	28
Pedmyre 11	NS5936057540	184
Pedmyre 12	NS5934057540	38
Pollok CP 01	NS5550062600	6
Pollok CP 02	NS5530061500	780
Provanhall	NS6676966244	0
Queens Park Duck Pond	NS5769862318	224
Roaden Burn Pond	NS4583561059	20
Robroyston LNR 01	NS6270068400	140
Robroyston LNR 02	NS6281368102	50

Pond name[1]	Nat. Grid Ref.	Max. no. frogspawn clumps counted[2]
Robroyston LNR 03	NS6281368102	1511
Robroyston LNR 04	NS6271468730	0
Robroyston LNR 05	NS6289568414	0
Rosshall Park Pond	NS5210863127	0
Seven Lochs 1 (Hogganfield LNR)	NS6424566910	59
Seven Lochs 2 (Hogganfield LNR)	NS6451867178	23
Seven Lochs 3 (Hogganfield LNR)	NS6471367262	0
Seven Lochs 4 (Hogganfield LNR)	NS6467067291	0
Seven Lochs 5 (Hogganfield LNR)	NS6464767295	0
Seven Lochs 6 (Hogganfield LNR)	NS6462767301	0
Seven Lochs 7 (Hogganfield LNR)	NS6460567322	0
Strathaven Park	NS6695644871	418
Windlaw 01	NS6039158070	0
Windlaw 02	NS6034958057	0
Windlaw 03	NS6033458070	0
Windlaw 04	NS6034957988	0
Windlaw 05	NS6025357904	0
Windlaw 06	NS6022357903	0
Windlaw 07	NS6018957902	0
Windlaw 08	NS6018357939	0
Windlaw 09	NS6023157953	0
Windlaw 10	NS6020057900	0
Windlaw 11	NS6020057900	0
Windlaw 12	NS6025157941	0
Windlaw 13	NS6029457974	0
Windlaw 14	NS6031257901	0
Windlaw 15	NS6040157811	0
Windlaw 16	NS5984258104	1
Windlaw 17	NS5961358040	3
Windlaw 18	NS5970358022	1
Windlaw 19	NS5957357994	0
Windlaw 20	NS5966657995	41
Windlaw 21	NS6037657836	0
Windlaw 22	NS6043657797	3
Windlaw 23	NS6039958120	0
Windlaw 24	NS6059157999	0
Windlaw 25	NS6056458019	1
Windlaw 26	NS5989858183	0
Windlaw 27	NS6063158018	0
Windlaw 28	NS6033657974	0
Windlaw - Bonus 1	NS5962058040	19
Windlaw - Bonus 2	NS5955057910	5
Windlaw - Bonus 3	NS5957057910	0
Windyhill, Johnstone Puddle 01	NS4353761235	107
Windyhill Puddle 02	NS4353161235	3
Windyhill Puddle 03	NS4344761231	0
Windyhill Puddle 04	NS4344761231	0
Windyhill Puddle 08	NS4361661205	2

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Coastal Treasures of the Eastern Solway: a *Species on the Edge* project

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Species on the Edge is a consortium of seven conservation charities led by NatureScot, all of whom are dedicated to safeguarding a future for 37 of the rarest and most vulnerable species associated with Scotland's coastal and island habitats. With support from the National Lottery Heritage Fund, the partnership will deliver a national programme of works intended to mitigate the negative effects of environmental change and provide benefits for both local communities and wildlife. An underlying objective of this approach is to explore new ways of partnership working within the conservation sector while at the same time empowering communities to play a more active role in helping to protect their local environment.

There are nine species projects in total spread across seven project areas throughout Scotland. As area lead for the Solway Coast project area, Amphibian and Reptile Conservation (ARC) are proud to present Coastal Treasures of the Eastern Solway - a project through which we aim to engage with and empower local communities and landowners to help conserve Scotland's rarest amphibian, the natterjack toad (*Epidalea calamita*) (Fig. 1).

Fig. 1. Natterjack toad (*Epidalea calamita*). (Photo: Ben Andrew)

Most extant populations of natterjack toads in the United Kingdom are closely associated with coastal environments such as dune slack, sandy heath and upper salt marsh (or "merse"). In Scotland, the toad's range is restricted to the vice counties of Dumfriesshire and Kirkcudbrightshire and extends from Powfoot in the east of the region to Mersehead in the west; the population at Mersehead is the result of a translocation from neighbouring Gillfoot Bay about 25 years ago (ARC, 2018). The species was once considered to be locally abundant in some areas. However, since the late 1970s, the local population has declined dramatically and the species' distribution is estimated to have declined by more than half in the last century.

The natterjack toad is often referred to as a pioneer species, in reference to its proclivity for early successional or so-called "dynamic" habitat characterised by a lack of vegetation and abundance of loose substrate. Natterjack toads prefer to breed in ephemeral water bodies, meaning those that either dry up in late summer or become inundated with tidal water over winter, only to be replenished by rainwater the following spring. It is generally thought that they evolved this life history strategy to avoid competition from other amphibian species (e.g. the common toad *Bufo bufo*) and help reduce predator burden from aquatic predators, such as fish, during their developmental stages (Banks & Beebee, 1988). Such a novel life-history strategy, however, makes the species vulnerable to habitat loss as a result of agricultural intensification and afforestation, as well as from natural processes such as ecological succession. Phenomena such as seasonal drought and sea-level rise can also have disastrous effects on breeding success due to the premature desiccation or salination of breeding ponds.

In response to this plight, and through the concerted efforts of ARC staff and volunteers via the Coastal Treasures of the Eastern Solway project, we have endeavoured to conduct a rigorous population and habitat assessment of the species throughout its range in Scotland. The results will provide a robust baseline against which to make informed recommendations for appropriate habitat interventions. Working closely with landowners and custodians of the environment, we will co-design and implement a range of long-term, sustainable land management solutions, such as low-intensity rotational grazing, for the benefit of the natterjack toad and other wetland species, such as wading birds and the tadpole shrimp (*Triops cancriformis*).

The tadpole shrimp is of particular importance, as it is only known to occur in two locations in the U.K. - the New Forest in Hampshire and the Solway Coast. Similar to the natterjack toad, it too has adapted to breed in ephemeral waters, albeit those that occur within a slightly different hydroperiod from those typically preferred by the natterjack toad. Unlike the natterjack toad, however, tadpole shrimp eggs are able to enter a state of diapause that can last in excess of 25 years, during which they are able to withstand freezing temperatures and prolonged periods of drought while

awaiting the optimum conditions for development (Rogacki & Brysiewicz, 2021). The species was thought to have become extinct from the Solway during the middle of the 20th century. However, it was subsequently rediscovered at Caerlaverock around 2010. In an attempt to safeguard this enigmatic yet vulnerable species, the *Species on the Edge* partnership is overseeing efforts to reintroduce tadpole shrimp to their historic range at RSPB Mersehead by way of the translocation of eggs reared in captivity from sediment collected at Caerlaverock.

Through a diverse programme of multi-sensory activity, *Species on the Edge* will endeavour to raise awareness of the various threats to biodiversity, as well as to provide bespoke training opportunities through which to grow capacity for local participation in practical conservation and species monitoring, all of which is intended to engender a sense of community ownership with regards to the project and ensure a lasting legacy.

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The threats facing Scotland's herpetofauna, and what can be done about them

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As well as the overall threats facing all wildlife (habitat loss and degradation, and climate change, mainly) Scottish amphibian and reptile species can face some quite specific threats (Downie *et al*., 2019; McInerny & Minting, 2016). For example, mortality on roads is a major issue for common toads (*Bufo bufo*), linked to the mass migrations in the spring of adults to breeding ponds and in the autumn of juveniles from ponds. Great crested newts (*Triturus cristatus*) have a problem related to their patchy distribution in Scotland and their specific habitat needs: if a pond becomes unsuitable because of vegetation growth, there may be nowhere accessible for the population to migrate to. Charismatic but sensitive species like European adders (*Vipera berus*) may suffer from over-enthusiastic wildlife watchers, especially in these social media days when crowds can be rapidly assembled: current legislation limits disturbance to breeding birds, but there is little similar restriction on disturbance to active reptiles and amphibians (with limitations on interactions with great crested newts the main exception).

The following is a summary of the discussion that took place in a Discussion Topic session at which attendees were asked to assemble a list of the threats they thought our herpetofauna faces, and to make suggestions as to how these threats could be mitigated.

Climate change and habitat loss largely account for the decline in biodiversity across all areas of the world, but other factors can be particularly harmful to amphibians and reptiles. Road mortalities, especially for migrating toads and common frogs (*Rana temporaria*), along with gully pot entrapment have detrimental impacts on amphibian populations. One solution to saving toads and frogs from drowning in gully pots is via the use of ladders that can be inserted into drains, allowing animals to climb back out. Additionally, wildlife tunnels can provide a safer alternative route to crossing roads, eliminating the dangers of traffic and drains.

Pollution is another global threat to species persistence, but there is a lack of focus on the effects of pollution on herpetofauna – particularly reptiles due to their lack of semi-permeable skin. However, reptiles may be susceptible to pollution via bioaccumulation as they prey on animals directly exposed to pollutants. These sub-lethal effects are difficult to observe, especially at the population level, and hence are understudied. Anthropogenic noise pollution also disrupts herpetofauna as mating calls in the form of vibrations are interfered with. Chemical communication can additionally be affected by climate change as both increasing temperatures and carbon dioxide concentrations change the expression and composition of pheromones. These pheromones are important for mate recognition in reptiles, thus disturbance to these reproductive processes may have long-term effects on reptile perseverance.

Another type of pollution occurs in the form of anthropogenic litter. On one hand, rubbish items have been shown to be structurally useful for some amphibians – newts have been seen to lay eggs on plastic – but chemical seepage from litter is considered the main concern. Similarly, microplastics interact with chemicals that can disrupt normal physiological processes. Microplastics are often consumed by tadpoles which can cause blockages in their digestive tracts and also leads to muscle malformation, both of which can hinder development. Many studies have explored the effect of microplastics on fish, but few data have been created and quantified regarding amphibians, despite their ability to absorb and excrete toxic chemicals.

Other species, especially game birds, can be a danger to herpetofauna. Common pheasants (*Phasianus colchicus*) kill adders and other reptiles. Domestic dogs (*Canis lupus familiaris*) and domestic cats (*Felis catus*) also create problems for amphibians and reptiles, particularly adders and slow-worms (*Anguis fragilis*), by predating on them, but also via aquatic pollution to water bodies due to topical flea treatments, for example. Ongoing research is investigating the effect of the accumulation of flea treatment compounds on amphibian physiology and health. Furthermore, highland cattle (*Bos taurus*) are seen grazing areas surrounding ponds which can also lead to disturbance and herpetofaunal mortalities. An obvious solution utilised across Scotland is to erect fencing around the perimeter of ponds to prevent entry by dogs.

There is much controversy surrounding social media and, although social platforms can be useful for collaboration and sharing of information, global access to such information can lead to over-exposure. Therefore, disturbance to potential herpetofaunal sites has been amplified and this has led to researchers keeping information on known spots to themselves, or restricted to small communities, to prevent excessive numbers of people from flooding areas where herps are present. Sharing of false information is another issue with social media, meaning that inappropriate and

potentially damaging behaviours can be replicated all over the world without considering the wider implications. Hence, some regulation is needed: for example, to prevent the harvesting of frogspawn on a large scale.

The recently proposed relaxation of legislation for the protection of herpetofauna in the U.K. (Tse-Leon, 2024) has meant that now only IUCN-defined threatened species are considered in need of legal protection. Adders are hence assumed not to need protection due to their relatively high abundance across Scotland. It was debated whether legislation was ever originally followed and concluded that implications must be reinforced to prevent activities that cause disturbance. Even unobserved crimes such as dumping chemicals into ponds need to be monitored more effectively. Often, local walkers are the best source of consistent information regarding such events.

Finally, disease is a worldwide threat to fauna and flora, and examples of lethal pathogens for herpetofauna are the fungi *Batrachochytrium dendrobatidis* and *B. salamandrivorans* which cause chytridiomycosis in amphibians. As Scotland's climate is getting warmer and drier, with even drought occurring, it is thought that chytrid disease may thrive and hence increase its success in such conditions. Awareness around infectious disease in increasing, but further investigation into how such fungi evolve and invade new areas and species is required to protect Scotland's herpetofauna.

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Protecting Britain's wildlife laws: the need for vigilance, a saga for our times

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ABSTRACT

This paper describes how numerous conservation non-governmental organisations (NGOs) became aware of significant changes being made to the eligibility criteria of species currently (and in the future) afforded protection under the Wildlife and Countryside Act (1981) through the seventh Quinquennial Review (QQR7). The changes mean that an animal or plant species will be protected only when it is in imminent danger of extinction as defined by the highest categories in the IUCN red listing process, or those identified as European Protected Species, rather than being recommended for inclusion by experts either due to persecution, population decline or other threats. These changes, and the way they became known, stimulated a collaborative effort by NGOs to have the new eligibility criteria for the listing of species re-examined. This case also alarmed the conservation community over the way the U.K. government could use its new powers to review environmental legislation, following withdrawal from the European Union.

INTRODUCTION

Froglife is a wildlife conservation charity focused on the protection of U.K. reptiles and amphibians and their habitats. This is achieved through three main workstreams:
(1) Transforming Landscapes - practical improvements to habitats including pond restorations and creations.
(2) Transforming Lives - engagement with members of the public through projects to stimulate interest and activity in amphibian and reptile conservation. In 2022, Froglife worked directly with over 45,000 people through projects and a further 40,000 people through social media platforms. Froglife's USP (Unique Selling Point) is engaging diverse audiences that are new to conservation.
(3) Transforming Research - projects that collect data on amphibians and reptiles, and collaboration with a variety of research institutions to carry out research into these species.

Although Froglife has been an active member of Scottish Environment Link for many years, the organisation has not otherwise been much involved with policy previously.

THE STORY

It is 40 years since the Wildlife and Countryside Act (1981) was brought into law. The Act provides primary legislation for wildlife protection in the U.K., and for many species it is the only legal protection that they receive. There are different levels of protection for different species and the species that are included are listed on two schedules: Schedule 5 is for animals, including species such as the red squirrel (*Sciurus vulgaris*), and Schedule 8 is for plants, including species such as the common bluebell (*Hyacinthoides non-scripta*).

On the morning of 17th June 2021, Froglife received an e-mail from Amphibian and Reptile Groups (ARG) U.K. drawing attention to changes that were being proposed in the latest Quinquennial Review (QQR). Every five years, the species listed in Schedules 5 and 8 of the Wildlife and Countryside Act are reviewed and that process is coordinated by the U.K. Joint Nature Conservation Committee (JNCC). (The Wildlife and Countryside Act was passed well before the devolution of the Scottish Parliament and the Welsh Assembly, which now have responsibility for environmental and conservation policies and practice.) JNCC works to ensure that wildlife conservation policy across the U.K. remains essentially unified.

Many of the species that are currently listed in Schedules 5 and 8 are included because experts have recommended their inclusion, usually due to their persecution, population decline or other threat. The e-mail came through on the morning of one of Froglife's Trustee meetings. The Trustees were discussing this before going into their formal meeting and were greatly alarmed by the fact that eight out of 13 U.K. amphibians and reptiles were set to lose the protection afforded by the Wildlife and Countryside Act. These species included many of our common and widespread species, e.g. grass snakes (*Natrix natrix*), common frogs (*Rana temporaria*), common toads (*Bufo bufo*), small newts (Pleurodelinae), and other species. The Froglife Trustees asked me if I could look into what was being proposed, what the details were, and how Froglife could get involved in opposing it. One of the first people that I then spoke to was Nida Al-Fulaij from the People's Trust for Endangered Species (PTES). Together, we first organised NGO meetings to find out what was known about the changes being made and the effects these would have. These meetings were useful to share knowledge and concerns and then devise a joint plan for the next steps.

In the latest review, QQR7 and, in a change to the normal process, the review group consisting of JNCC and the three country conservation bodies - Natural England, NatureScot and Natural Resources Wales (the Northern Ireland equivalent, the Council for Nature Conservation

and the Countryside, operates under different legislation, although it does co-operate with JNCC), changed the eligibility criteria by which species are currently, and in future will be, listed. This was presented in an Information Pack as a *fait accompli*. The decision to change the eligibility criteria was already in place and the consultation that they were then putting out was to obtain information from interested partners about the species that may be listed in the new version of the schedules. The way that the criteria were changing was that species would be protected only when they were in imminent danger of extinction as defined by the two highest categories of the International Union for Conservation of Nature (IUCN) Red List (CR = critically endangered and EN = endangered) (https://www.iucnredlist.org/), or those that are identified as European Protected Species. This was therefore a significant change from what had happened before (where experts could recommend any species to be listed, provided they could make a good case for why this was needed). This greatly concerned Froglife and many the other organisations, because it meant that many species would lose their protection, and that the decision had been made without due consultation on the change to the eligibility criteria, and without consideration of the concerns raised by the NGOs that had been aware of the changes.

Looking at the problem in more depth, the Information Pack was highlighting that a large number of species would no longer have legal protection from killing or sale. The number of species losing protection was not quantified in the original Information Pack. It contained two lists of species that would be affected, represented only by their binomial scientific names. Because they did not match up as lists, it was not easy to see which species would lose their protection. I calculated that 334 species would lose their protection, including eight out of 13 amphibians and reptiles, as well as many iconic and persecuted species such as the mountain hare (*Lepus timidus*). This was obviously of great concern to Froglife and other groups such as PTES. What was not clear at that point was whether this was a known consequence or whether the changes had been made to benefit certain taxa without consideration as to how other taxa would be affected and which would then be lost from the Schedules. This appeared to greatly weaken our environmental protection at time when we are facing both biodiversity and climate crises when our wildlife should be getting more protection rather than less.

COP26 (Conference of the Parties 26) was approaching and Prime Minister Boris Johnson was very keen to show that the U.K. was at the very forefront of environmental protection and leading the way in the Climate Crisis. It was also a period of huge political upheaval with three successive Prime Ministers in a matter of months announcing new policies, such as Liz Truss's Investments Zones, which would have had serious consequences for U.K. countryside and wildlife.

In response to the QQR7 Information Pack and the changes being made, within around two weeks, the group of NGOs that had come together agreed on an open letter that was sent to the review group, opposing the changes and calling for a public consultation on the decision to change the eligibility criteria before proceeding with the planned timetable. Over 30 wildlife conservation NGOs supported this – including PTES, ARG UK, GNHS, Bumblebee Conservation, RSPB, RSPCA, Wildlife and Countryside Link, Wales Environment Link, Freshwater Habitats Trust, Scottish Environment Link, and the Wildlife Trusts. There was no earlier opportunity to question or oppose the fundamental changes that were being proposed: it was possible to comment only on which species should or should not be included. This first letter asked the review group to stop, pause the proceedings, and allow us to talk to them about these fundamental changes. We asked for the consultation period to be extended and for the scope of the consultation to be expanded to include that element. This action received some initial publicity including an article in *The Guardian* newspaper, as well as through the NGO websites and social media.

The QQR7 review group then held some NGO stakeholder meetings and began a dialogue with the NGOs who engaged with the process. The review group extended the consultation phase of QQR7 and broadened its scope, as we had asked. They also made exceptions for many of the species that would have lost their protection, so that they would remain listed. The NGOs, however, continued to insist that the criteria should not be narrowed to exclude vulnerable species that are still classed as in danger of extinction by the IUCN Red List. We wanted to establish a clear process that could be applied fairly to all species that are included in the Schedules now and in the future. It did not seem to make sense to initiate a new system at a time of biodiversity crisis when we know that some species require more protection, not less. We also know that for many species sufficient data are not available to determine their Red List status but this does not mean they are not in reality at risk of extinction.

The consequences of these actions were that the QQR7 Information Pack was updated to include the species where exceptions had been made, and the NGOs completed the consultation to feed in individual concerns about the review's new approach. A second open letter, signed by over 45 NGOs, was issued to formally state the agreed view that the proposed changes to the eligibility and decision criteria were not fit for purpose.

That terminated the JNCC process of consultation. Following this, a public consultation report was published by JNCC. This was disappointing in that it did not appear to acknowledge that there was any organised opposition to the changes that had been outlined. The reader would not know that 45 NGOs, including some of the leading British NGOs with largest

membership groups, were in opposition, had much background support, and had expressed a high level of concern. We therefore felt it was important that we alerted the Government Ministers that are responsible for making the decisions on whether to adopt JNCC's advice on these changes, so that they knew the full back story, and were aware of the concerns that we had highlighted. Froglife and PTES, on behalf of the NGOs, wrote to the Ministers in the three devolved nations and alerted them to what was going on. We were then invited to meet with Julie Jones MS from Wales and have been in an ongoing dialogue with Ministers since then. When we had the meeting with Julie Jones MS, Liz Truss had become Prime Minister and, the week before our meeting with Julie Jones MS, was talking about investment zones and various plans that would have undermined our environmental laws. It seemed that our concerns were coming true in that QQR7 would be the "canary in the mine" and the first test of reviewing environmental protection legislation, setting a precedent for future changes post-Brexit. It was in the midst of these new government changes that we took the opportunity to invite colleagues from the RSPB and Wildlife and Countryside Link to join the meeting with Julie Jones to discuss some of these broader issues, such as the Levelling Up and Regeneration Bill and the threat to the Habitat Regulations as well as the QQR7. It was a very positive meeting, and we were encouraged to continue the dialogue.

The Ministers are due to publish the advice from JNCC. None of the three Governments of the devolved nations have yet published this advice and we still do not know what JNCC's final advice was to those Ministers. In the meantime, during successive changes of Government and appointments of new Ministers we, as a group, continue to apply pressure.

CONCLUSIONS

In terms of what can be learned from this experience, the key points are that:

(1) Partnerships and collaborative working are essential. This brings together skills from different groups, and shares the load at a time when British wildlife laws are under threat on an unprecedented scale. Froglife now has to be involved in policy and has become a member of Wildlife and Countryside Link (in addition to Scottish Environment Link) as a result of working closely with the organisation on this issue. Organisations have to work together to spread the load; there are too many ongoing issues for any single organisation to lead on them all.

(2) Whatever your background, you can make a difference. "Naïve" questions from non-experts can lead to a productive release of information.

(3) Seize opportunities when you can.

(4) Keep applying pressure.

More information is available via the following links:
https://www.froglife.org/changes-to-the-wildlife-and-countryside-act-1981/
https://jncc.gov.uk/our-work/qqr-7/
https://biaza.org.uk/news/detail/blog-what-nobody-is-saying-about-the-threats-facing-our-uk-wildlife-legislation

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Should the international trade in wild-caught amphibians and reptiles be abolished?

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Cardoso *et al.* (2021) issued a stark "warning to humanity" concerning the international trade in wildlife. The trade:

- Threatens population stability and sustainability in the wild.
- Helps the spread of invasive alien species.
- Helps spread new diseases both to native wildlife and to humans and our domestic animals.
- Is often illegal and has links to other criminal activities such as the narcotics trade.

Their paper did not mention another adverse aspect of the trade: the negative impact on animal welfare, at all stages of the process, from initial capture to international transportation, to sales outlets, and finally to largely unregulated collectors' homes. Mainly on welfare grounds, the British Veterinary Association (2023) has concluded that the international trade in wild-caught amphibians and reptiles should be abolished.

The trade is sometimes defended on two grounds:

- Owning a captive reptile or amphibian can be educational. However, this can be based on captive-bred animals, rather than on wild-caught individuals.
- The income generated by capturing and selling wild amphibians and reptiles for the trade is beneficial to people in poor rural areas, and provides an incentive for conservation (Tapley *et al.*, 2011). On the other hand, do the collectors receive a significant income boost, and is there a demonstrable positive effect on conservation?

The following is a summary of the remarks made during a Discussion Topic session at which the attendees were asked to discuss: (1) the pros and cons of a trade ban (possibly continuing to allow trade for limited purposes such as research and conservation), and how such a ban could be implemented; and (2) the question of whether or not NGOs working for the conservation and welfare of amphibians and reptiles should adopt a trade ban as policy.

A robust discussion, involving about a dozen conference participants, took place with regards to trade of wild-caught amphibian and reptiles. Whilst in an ideal world a ban would cease the trade in wild-caught amphibians and reptiles, it was considered that it would more likely send the trade in wild-caught amphibians and reptiles underground. It was put forward that this would have the following likely consequences for the local populations:

- An increase in the fee that people would be willing to pay for wild-caught animals in order to obtain rare or unusual specimens that may not be available from captively-bred sources, thereby increasing the black market in these animals.
- Reduced welfare conditions for wild-caught and smuggled amphibians and reptiles, leading to an increased mortality and injury to the animals.

Discussion followed over methods of regulating the trade of wild-caught animals, such as the introduction of permits, limiting the number and populations of amphibians and reptiles that could be captured. However, concern was expressed with regards to how this would be implemented, and what process could be put in place to monitor the compliance with the permits. The integration of such a system with regards to the implementation being managed by local communities was considered, since they would have a greater interest in establishing a long-term sustainable trade than in short-term gains. The practicalities of setting up and funding such a system were considered difficult. However, it was considered a possibility that such a system could be linked in with habitat creation and enhancement schemes.

It was proposed that all keepers of amphibians and reptiles should be registered along with their animals. Concern was expressed, as this may negatively impact the welfare of animals whose keepers were not registered and might avoid taking sick or injured animals to vets, due to the risk of prosecution. It was then proposed, as an alternative, that the traders in these animals should be registered, and that registration should come with strict criteria such as agreed welfare conditions, biosecurity protocols etc. No conclusions were reached about the optimal way to implement such a system and what unintended consequences it might have.

One of the discussion participants (Alexia Hesten) had presented a poster on this topic at the conference, and is currently working towards a Ph.D. on the wildlife trade at Liverpool John Moores University. The results of her research should provide guidance in the future.

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Book Reviews

Nudibranchs of Britain, Ireland and Northwest Europe

Bernard Picton & Christine Morrow
Princeton University Press (Wild Nature Press series), 2nd Edition, 2023. 360 pages, paperback with many colour photographs. ISBN 9780691230696.
£35.00

Nudibranch sea slugs with their bright colours are popular subjects among underwater photographers. In British and nearby seas, they are generally only a few cm in length though the largest, *Tritonia hombergii*, may attain 20 cm and the smallest interstitial species, which squeeze among sand gains, are only a couple of mm long.

This new addition to the Wild Nature Press series of identification guides is an updated version of the 1994 *Field Guide to the Nudibranchs of the British Isles* by the same authors. The authors are both from Belfast and both long-in-the-radula experts on nudibranch sea slugs and allied molluscs. With the expanded geographical coverage now including Northwest Europe from Brest in France to Bodø in Norway, the number of species included has increased considerably from 108 to over 195 with a corresponding increase of the volume size from 142 to 360 pages.

There is a lot packed into this tome with large photos and rather small text. The introduction is relatively short, at 15 pages, and covers species nomenclature, food and feeding, reproduction, anatomy, how to find nudibranchs, and how to record them. There is a short glossary of morphological and ecological terms and also a fascinating glossary of species names and what they mean. The latter is especially welcome as few nudibranchs possess common names and the scientific names are so much more memorable (dare I say enjoyable) if their meaning is understood.

A detailed table of the food preferences of 144 species is included which is very helpful as many nudibranchs have very specific dietary requirements and are frequently to be found on the relevant food source, helping with identification. The commonest foods are hydroids, bryozoans and sponges, but may also include tunicates, entoprocts, barnacles, sea-pens and soft corals. One genus, *Calma*, specialises on eggs of gobies or clingfish (Gobiidae). Several pelagic nudibranchs are also included, such as *Fiona pinnata* and *Glaucus atlanticus*, which feed on goose barnacles, and siphonophore and velellid jellyfish, though few pelagic nudibranchs have yet been recorded from the shores of Europe.

One interesting aspect of nudibranch biology which has been overlooked is the frequent occurrence of infestation by parasitic copepods, relatives of the well-known sea-lice that occur on salmon. These include the ectoparasitic copepod *Doridicola agilis*, which can be seen skipping over the host's surface. It has various colour morphs which often contrast sharply with that of the host making them quite conspicuous. More insidious are the endoparasitic splanchnotrophid copepods which are concealed within the host's body but extrude pairs of large white egg sacs through the host dorsum. Again, these egg sacs are very conspicuous and easily mistaken for nudibranch spawn. One of the photographers contributing to this volume, David Fenwick, has also produced beautiful images of nudibranchs parasitised by copepods on his AphotoMarine website (https://www.aphotomarine.com/copepoda_sea_lice.html) and these would be worthy of inclusion in any future nudibranch volume.

By far the bulk of this book - 335 pages - deals with the species accounts of nudibranch and allied molluscs. These cover over 160 nudibranchs (clades Doridina and Cladobranchia), a smaller number of other sea slugs (Acteonoidea, Cephalaspidea and Sacoglossa), sea-hares (Aplysiida), and six-gilled slugs (Pleurobranchida). Almost every species has a two-page spread including three large photos and notes on descriptions, key characteristics, similar species, ecology, and distribution. The photos are in resplendent colour including both field photos with the sea slugs in their natural habitat (often on the host/food species and/or with spawn coils), as well as beautiful dark field studio images which accentuate the colours and morphological features. Many different photographers have provided images for this book as indicated in the acknowledgements.

The authors themselves have contributed hugely to the study of nudibranchs over many years. Prior to the publication of the Picton & Morrow photographic guides, the nudibranch enthusiast had to rely on T.E. Thompson's Linnean Society Synopsis (No.8) *Molluscs: Benthic Opisthobranchs* (1988) which was based mostly on black and white line drawings and only a small number of colour photos. The digital photography revolution and the advent of DNA barcode analysis, to unravel species complexes, have both had a significant impact on the study of nudibranchs. Many species within the new guide have only been recognised within the last few years including several described by the authors themselves. Moreover, they have had the honour of having two species (*Atalodoris pictoni* and *Trinchesia morrowae*) named after them by colleagues – the ultimate accolade for a taxonomist.

Several of the species depicted are still in a state of taxonomic flux or have yet to be formally described. In this respect it would be useful to further explain how species are distinguished using DNA barcodes. The

statement about separating *Trapania pallida* and *T. lineata* on page 66 is confusing as is the inclusion of two different *Coryphella* species on pages 206/208 which are said to have "identical" DNA barcodes. Are we to assume that the two nominal *Coryphella* are regional genetic morphs of one species? If so, why have they not been synonymised?

A number of the nudibranch species appear to have arrived on the southern shores of Britain only in recent years and may be part of a northerly migration trend, perhaps related to warming seas. These include flamboyant species, such as *Babakina anadoni,* which are unlikely to have been previously overlooked. However, other species from south-west Britain remain rather rare (*Atagemma gibba*), very rare (*Thordisa azmanii*) with a single record, or have mysteriously disappeared from both Britain and Ireland over the last 30 years (*Greilada elegans*). It is clear that there is still a lot to be learned about the nudibranchs that occur in British waters. The distribution descriptions in this guide would benefit from the addition of dot maps, which would better enable a species' ubiquity or scarcity to be gauged at a glance.

In conclusion the new nudibranch volume is an excellent and authoritative field guide, which will hopefully encourage naturalists to delve more deeply into the sea slug's realm. It is accessible to both amateur and professional naturalists, whether rock-pooling, snorkelling or carrying out underwater photographic surveys.

Myles O'Reilly

Plant-Life: A Walk with Nature

Edward Bent
Self-published via The Great British Bookshop, 2023.
240 pages, paperback. ISBN 9791221009576.
£21.00

I had a bit of a dilemma reviewing this book. This was because I found it hard to assess the anticipated readership. The author's aim is to make the reader appreciate plants and develop a sense of their value, and to understand their form and function and interaction with other life forms, including humans - including at artistic and cultural levels. This is conspicuously ambitious, and so to make it more palatable the main content of the book is divided into five sections that are linked as if the reader is being taken on a guided walk through nature. It seems like a great idea, but there is a huge mix, from botanical naivety, through philosophy and poetry, then up-to-date botanical research. Hence my problem. However, the author is well equipped for this, with a degree in botany, research experience, teaching and life experience in many countries of the world. His background also includes marketing. I wondered if the title *Plant-Life*, so very like the well-respected charity "Plantlife", reflected any of these experiences.

Alas, before beginning this walk, the reader has to stumble through many, many pages: a Preface, Reviews, Acknowledgements, Tabled list of contents, plus an Introduction where the contents are summarised. At last, the walk begins and I can put my boots on.

Section I is divided into three chapters and is where, on our walk, we are encouraged to admire and notice plants, (note, "plants" throughout mainly relates to flowering plants only). Their interaction with the environment is looked at, largely targeting non-botanists and a little irksome at times in use of language if you are a botanist. However, a happy spring would have been back in my step in Section II, which contains four chapters full of information on plant physiology and biochemistry, and also covering the interaction of the whole plant with the environment above and below ground. This is really good stuff.

Section III, and I am beginning to trip again. The author classes this section as holistic considerations, a mix of mathematics, ecology and aesthetics. Take a deep breath and move on to Section IV - evolution and biodiversity. This section is rich in fascinating information. It deals with the co-evolution of plants and insects, biodiversity and interaction with humans, and variation in bees (with reference to Dave Goulson's research on this subject). Pollination and evolution of metabolic pathways are covered and well up-to-date. Epigenetic inheritance in evolution in relation to biodiversity is discussed and even the role of bacteria and cyanobacteria in evolution at biochemical and molecular levels. The interaction of humans with biodiversity is evaluated for food, fuel, medicines, education and well-being. Much in this section is thought-provoking and is well illustrated and tabulated throughout. We may be approaching overload and tired feet on our walk, but we have more to think about ahead.

Section V looks at "Earth systems as a whole", taking us through immediate and far-reaching topics in relation to human interaction - climate change, food yields, pollution, education and life-style, and "Going green". A considerable mix of topics here, which includes art, mathematics, politics, science. It revisits educational topics, which are further examined and discussed. This is classed as a descent at the end of your walk. Your brain and your feet might be tired by now. Very thought-provoking and you thought you were finished, but you still have the "Debriefing", a Glossary of Terms and a substantial Bibliography including suitable references for each chapter. After 240 packed pages, our walk is now complete!

In conclusion, I am truly impressed with much of the content of this book, but perhaps the author has been too ambitious in covering such a wide spectrum of topics. Consequently, while the seasoned botanist and natural historian could find certain parts rather simplistic, the less well-versed may find parts too complex. Who is the target readership? Of one thing I am certain, strong boots and stamina are required for this walk with nature and there are some rewards for all.

Alison Moss

British Craneflies

Alan Stubbs

British Entomological and Natural History Society, 2021. 434 pages, hardback with 31 black and white plates and 32 colour plates, and numerous line drawings in the key section. ISBN 9781899935093. £36.00

British Craneflies covers six families of Diptera comprising over 350 species – all instantly recognisable by their long dangly legs. It includes, in addition to the four families of "true" craneflies (superfamily Tipuloidea) - Cylindrotomidae (damsel craneflies), Pediciidae (hairy-eyed craneflies), Tipulidae (long-palped craneflies), and Limoniidae (short-palped craneflies) - two further families that are similar, i.e. Ptychopteridae (fold-wing, or phantom craneflies), and Trichoceridae (winter gnats).

Craneflies, particularly the Tipuloidea, are hugely important ecologically, with the larvae and adults of many species being significant components of food chains in many habitats. The breeding of many upland waders such as golden plover (*Pluvialis apricaria*) coincides with the emergence of abundant craneflies during summer, and there is evidence that this may be affected by climate change (https://research.manchester.ac.uk/en/publications/warmer-springs-advance-the-breeding-phenology-of-golden-plovers-p).

The book is packed with interesting biology and life-history observations of both larvae and adults, their associated habitats, predators and their conservation. There is an impressive amount of information about the various families, subfamilies, and genera, with a detailed account for each species covering its description, habitat preferences, phenology, and an indication of its distribution in the U.K. and Ireland.

The keys focus on wing venation and genitalia (as do many other Diptera keys), but these are well described and illustrated with some wonderfully detailed drawings and colour photographs which are really helpful, and it is worth mentioning that tricky dissection of the genitalia is not required. Anyone who has chased a daddy-long-legs around the room in late summer will be aware of how readily their legs fall off – so thankfully legs are generally optional extras in most of the keys!

There are many species that the reader will quickly be able to recognise in the field, such as the large and well-patterned *Tipula maxima* and the colourful "tiger" craneflies - *Nephrotoma* spp. and *Pedicia rivosa*, and the autumn cranefly *Tipula pagana* the wingless females of which can be spotted on urban walls and trees. There are many common species that can be found in any garden, as well as rarities associated with ancient veteran trees, peatlands or submerged rotten wood. Craneflies are under-recorded in Scotland, so there are lots of opportunities for interesting finds and gap-filling!

Craneflies do not often attract the same interest as the more colourful hoverflies, but they are equally fascinating, and so it is to be hoped that this book, with its keys and ancillary information, will help foster a wider interest in the group.

Richard Weddle & Scott Shanks

Discovering Scotland's Butterflies

Paul Kirkland

Pisces Publications, 2022. 232 pages, hardback with colour photographs and maps. ISBN 9781874357995 £29.95

Paul Kirkland worked for Butterfly Conservation Scotland for 25 years, and so he is in an ideal position to know about Scotland's butterflies. His book is the first publication looking at all of Scotland's butterflies since George Thomson's *Butterflies of Scotland*, published in 1980. Much has changed since then. Climate change, loss of habitats and other factors have led to dramatic changes in the fortunes of the butterfly fauna and this book summarises the current (2022) situation. There are introductory chapters on "butterfly basics" and on "Scotland's landscapes and habitats". For each species there is information about its status in Scotland, its distribution and good places to see it, flight period(s), larval food plant(s), along with a general description of the butterfly and its ecology. There are excellent photographs throughout of adult butterflies and often their life stages, and of some notable localities.

The other thing that has changed since 1980 is the amount of interest in Scotland's butterflies. There are far more knowledgeable enthusiasts now who search for, study, record and, above all, enjoy the 36 species regularly seen here. The author invited several of these people to submit anecdotes about particular butterflies, which have been included. This makes the book particularly good, as many very interesting personal observations are included, some of which explain what it was that led to these individuals getting "hooked" on butterflies.

Overall, this is an informative book on Scotland's butterflies, with much added interest, making it a good read in its own right.

Richard Sutcliffe

Ancient Sea Reptiles: Plesiosaurs, Ichthyosaurs, Mosasaurs and More

Darren Naish

Natural History Museum, London, 2022. 192 pages, hardback illustrated. ISBN 9780565095345. £20.00

My initial impression of this book is that it is a good sized, well-illustrated, contemporary, and affordable plunge into the aquatic realm of Mesozoic reptiles. After reading the book, my opinion has not changed. Darren Naish is a skilled science communicator who already has several books to his name in the field of palaeontology and cryptozoology. He set up the Tetrapod Zoology weblog in 2006 (https://tetzoo.com/) which covers many tetrapod-related topics and has appeared in, advised on, and contributed to, quite a number of popular television and radio programmes. In

addition to all this media involvement, he has published a substantial body of scientific research on dinosaurs, pterosaurs, fish, turtles, and, of course, marine reptiles of the Mesozoic.

There have been several books on ancient sea reptiles in the recent past such as *Prehistoric Marine Reptiles: Sea Monsters During the Age of Dinosaurs* (Judy Massare, 1991), *Ancient Marine Reptiles* (Jack Callaway and Elizabeth Nicholls, 1993), and *Sea Dragons: Predators of the Prehistoric Oceans* (Richard Ellis, 2003). All these books were of their time (and at least one was very academic) and the latest one was published exactly 20 years ago. Although these books still make some useful contributions to our understanding of the development of scientific thought on these reptiles, they are now becoming quite dated and there was certainly a need for a new, substantial book on this topic. This is where Naish floats in with his contemporary perspective.

Naish begins with three chapters that help to contextualise the marine reptiles. The Introduction covers the changing shape and connectivity of their seas, their changing climate, and the history of their discoveries – with a special section dedicated to Mary Anning. The second chapter covers how the different marine reptiles relate to each other – with the exception of the enigmatic turtles which are at least considered to be highly modified diapsids. Like the turtles, ichthyosaurs were once considered to have non-diapsid origins but are now thought to be closer to sauropterygians which leaves little doubt as to their diapsid origins. The evolution of the marine reptiles is still a contentious area of research which is sensitively approached by Naish. The anatomy of these animals forms the third chapter where he discusses the science of locomotion, feeding styles based on tooth shape and skull morphology, flexibility of the fins and necks, the body shape and skeleton as well as soft-tissue and cartilage preservation. It was important that these topics are covered in order to understand the huge variety of forms represented in the next six chapters.

From the lesser-known groups and strange-looking sauropterygians (like my favourite *Atopodentatus* which has a snout like the brush-head of a hand-held vacuum cleaner) to the better-known groups like the ichthyosaurs and plesiosaurs, Naish covers many of these groups based on their morphological characteristics and differences. The ichthyosaurs are placed into a chapter on the "shark-shaped reptiles", whereas the plesiosaurs are in the chapter on "long necks, big mouths". This appears to be a practical and accessible way of distinguishing between the major groups as well. Palaeontologists mostly rely on morphology for their taxonomies and so, conveniently, did these animals.

The last chapters mop up the remaining marine reptiles. Some of the Mesozoic marine crocodiles were very different from their extant cousins - some of them were highly modified to have fins rather than feet and a tail fluke to support a fully marine mode of life. Predators like the mosasaurs are mostly common towards the end of the Cretaceous immediately prior to the big extinction event. They also had a tail fluke and were very diverse from small species to giants, from shell crunchers to apex predators. New forms of these animals are being discovered every year in places like Morocco's Oulad Abdoun Basin as the phosphate deposits are still being exploited. The final chapter covers the sea turtles which were once a more diverse group within the clade Americhelydia of which only the Chelonioidea survived the end-Cretaceous extinction until today Some of these grew to immense size like the impressive *Protostega* with a 3 m shell length and the enormous *Archelon* that grew up to at least 4.6 m in length. Within the picture credits, Naish shows that he is an accomplished artist as well as writer, having produced many of the illustrations of these extinct animals associated with the cladograms.

Much has happened in the science of palaeontology over the last few decades and our understanding of these fascinating animals has advanced in huge hydrodynamic strokes. Even now, new discoveries are being made that will change our understanding of these beautiful beasts – not making Naish's book obsolete but merely adding to the body of knowledge. Naish's book will be a useful book for the student of palaeontology, and related sciences, providing an essential introduction to the diversity of marine reptiles during the Mesozoic. As a well-illustrated and well-written book, it will also be of use to those with a penchant for all things dinosaurian as a digression from the terrestrial into the (mostly) non-dinosaurian marine realm (marine birds, which Naish briefly mentions in Chapter 4, are the closest he gets to mentioning dinosaurs in this environment). I enjoyed reading it, and read it several times, finding new information at each reading.

Ancient Sea Reptiles will continue to excite and encourage a new generation of palaeoscientists to dive into a sea of discoveries that is still very much fluid. Discoveries that will revolutionise our understanding of the Mesozoic environment and the ecology of the organisms within.

Neil D.L. Clark

The Forest Guide: Scotland: Copses, Woods and Forests

Gabriel Hemery
Bloomsbury Wildlife, 2023. 320 pages, paperback with many coloured photographs and maps. ISBN 9781472994646.
£25.00

At first one might think that it is a fairly prodigious task to write a guide to the forests of Scotland. The author points out, however, that he has restricted the work to 365 forests so that selecting sites to include was quite a task. The book is far more than simply a guide to Scotland's forests, as soon becomes abundantly clear. The introduction is well worth a read, dealing as it does with Scotland's geography and trees, a summary of the most notable sites, trees and natural history, Scotland's

forest history, Gaelic language and place names, and forest ownership.

No such guide would be complete without clearly labelled maps. These maps are found towards the back of the book apart from the Caledonian Pinewoods map which is located at the start of the region labelled "Highlands". It seems to have been considered that placing all but one of the maps together at the end of the book is better than at the start of each section. The country has been divided into 14 different regions with an introduction at the start of each, which is of considerable interest. They are placed alphabetically and are also clearly found on the Contents page. Each of the 365 sites has been allocated a number so that they may be found easily on each of the maps. In addition, each site has a six figure OS map reference, explorer map number as well as a ten digit access point number with the relevant what3words reference and postcode. Furthermore, each has its ownership detailed; its designation, e.g. LNR (local nature reserve), SAC (special area of conservation), SSSI (site of special scientific interest) and others; its area in hectares; its forest type, *viz.* broadleaved, conifer, mixed, Caledonian pinewood, montane, temperate rainforest or Atlantic hazelwood; and ease of access.

Scattered through the book are eight very informative articles about Atlantic hazelwoods, red squirrels, temperate rainforests, Arran whitebeams (*Sorbus arranensis*), Caledonian pinewoods, Trees for Life, arboreta and Scottish plant hunters. Nowhere, however, are these interesting articles indexed.

The text is illustrated with many quite stunning photographs, including lichens and moss-covered stems, female catkins of alder (cones), witches broom, fungi, birds such as tree pipit perched on a dead Scots pine, roe deer part-hidden in foliage, butterflies such as small copper on an ox-eye daisy, ancient tree boles such as field maple, bark of Scots pine, natural regeneration of Scots pine at Tentsmuir in Fife, leaves of the Arran whitebeam, ancient beech at Cartland Craigs, Lanark. These photos give a great impression of the many fine locations referred to in the text. Records mentioned include the most northerly natural oakwood in Britain (Loch a' Mhuilinn, near Scourie), the most southerly remnant Caledonian pinewood site in Scotland (Glen Falloch, near Crianlarich), the most westerly forest in the guide (Langass Wood of lodgepole pine and Sitka spruce, Lochmaddy, North Uist) and the most southerly site in the guide (Physgill Glen, broadleaved, Whithorn). The introduction includes a section headed "Notable sites" in which the highest altitude, most remote, tallest, rarest trees and other records are listed.

In a book of this quality, criticism seems churlish. Errors exist, however, some being more important than others. Under a section on Geography, the Great Glen is not part of the Highland Boundary Fault as stated; under Glen Falloch "conversation" should read "conservation"; under the Black Wood of Rannoch reference is made to pine regeneration but not to oak regeneration, which the Society noticed some years ago. Reference to Glasgow is restricted to the Botanic Gardens and to Kelvingrove Park. No mention is made of Pollok Park or Glasgow Green, two of Glasgow's richly endowed parks; but such comments could also be made of Edinburgh where there is no reference to Princes Street Gardens (Wheatley elms) and no doubt to other Scottish locations. Another shortcoming is the lack of any reference to International Conifer Conservation Programme (ICCP) plantings in a number of safe sites scattered through the country. This relates to the suitability of the climate of Britain, despite its latitude, for the growth of trees from many parts of the world, thus enabling endangered tree species to be planted under the auspices of the Edinburgh-based programme. Both of these drawbacks are related to the restriction of the number of sites in the guide to 365. Ownership of Glasgow Botanic Gardens is described as "Private: Friends of Glasgow Botanic Gardens". However, Glasgow City Council owns the Botanic Gardens, one of Glasgow's five city parks. In the comprehensive glossary, gymnosperms are described as a division of the flowering plants (angiosperms). In fact, they are a group of seed-bearing plants (spermatophytes) where the seeds are not enclosed in an ovary. Angiosperms have their seeds enclosed within a fruit that develops from the ovary.

This book is most useful to anyone interested in trees and wildlife who is travelling to any part of Scotland. As explained above, some important locations have been missed out but, arguably, this shortcoming is more than made up for by the plethora of locations that are mentioned within the guide.

The author is chief executive of a British forest caring charity, Sylva Foundation.

Bob Gray

The Atlas of Early Modern Wildlife: Britain and Ireland between the Middle Ages and the Industrial Revolution

Lee Raye

Pelagic Publishing, 2023. 408 pages, hardback. ISBN 9781784274078.
£45.00

This unusual book examines the wildlife of the British Isles in what is largely the pre-Linnean age. It covers some 160 species based on over 10,000 records, many of which use local names (with varying reliability) in multiple languages from New Latin to Cornish. It does encompass an age when Eurasian beavers swam in the River Ness without the need of re-introduction programmes, and wolves and Eurasian lynx generated hunting parties and not scientific conferences.

At the beginning, the author urges us to avoid several common preconceptions. Imagining that the past was a golden age when myriad species inhabited these islands in a state of harmony is dismissed as a fallacy; what we have now may perhaps be less but it is also different, and well before the Industrial and Agricultural Revolutions a number of species were dying out while others had yet

to appear. The "Little Ice Age" lasted nearly 150 years until the mid-1700s. It had devastating effects on our wildlife, including marine fish stocks, and we are arguably still climbing out of it.

There are many caveats which must be borne in mind when considering zoological atlases. First and foremost, they often map out the distribution of human recorders rather than the animals themselves. This was recognised as a deficiency at the time and occasional attempts were made to solve the problem by means of circulated questionnaires – a system of citizen science described here as "Baconian". Nevertheless, we are looking at a time well before the widespread nature recording which characterises our own age. Secondly, what people chose to comment on or to record leans heavily towards things we ate or hunted, or things which competed with human self-interest. Indeed, the author remarks that while the readers of his book will be interested in animals and their conservation for its own sake, this notion would be quite foreign to the naturalists of the time. Thus, mammals are reasonably covered but there is nothing smaller than a rat; invertebrates are limited to edible molluscs, crustaceans and starfish; the coverage of birds is strong on raptors, wildfowl, waders and gamebirds, but include very few passerines; newts are lumped into a single species which includes lizards; fish do well. Each species has two to three pages devoted to it. Topics include its modern conservation status, how early naturalists spoke or wrote of it, its distribution and a map – as well as a period woodcut of often alarming caricature. Bearing in mind how sedentary the general human population was at the time, naturalists who travelled were also inclined to record the absence of species in places they visited, and nobody bothered to record species that were presumably ubiquitous, such as house mice or sparrows. Names can be unreliable; I was surprised to learn that the great grey shrike (*Lanius excubitor*) was called the "night-jarr" in Northamptonshire.

There is an illuminating explanatory chapter at the beginning of the book. The recorders/authors were largely professionals - a quarter were physicians or apothecaries; a quarter clergy; a quarter men such as teachers, lawyers or army officers; and a quarter the idle (*sic*) gentry or aristocracy. A small number of women also wrote on natural history and Raye names some. Perhaps the thorniest problem that the author addresses is how reliable an old record is, bearing in mind that mythical creatures such as mermaids were still widely credited, barnacle geese were believed to come from goose barnacles (so an author might be tempted to record both where only one existed) and a monkey was hanged in Hartlepool as a suspected French spy. Raye shows where the most (and least) survey effort was made; Scotland does well overall, especially the Highlands and Western Isles. The degree of agreement between expected and reported distribution is subjected to an Exact Multinomial Goodness of Fit test which, at best, will make the reader's eyes glaze over and, at worst, will introduce a hint of suspicion – especially when he adds that "the Monte Carlo method was used to reduce computational demand". Nevertheless, these statistical evaluations have been essential to the creation of the distribution maps for each species. On these a dot is a specific named place, a shaded area is a county where the creature occurs, a cross-hatched area is one where the records are so poor that nothing can be deduced, and a blank space is an area of good recording where the species is not mentioned so that absence must be inferred.

More than 330 pages are devoted to the species Raye has included, and there are fascinating details at every turn. Choughs were found at Dover; in 1875 the corncrake was common in almost every county of Britain and Ireland until a change in crop rotation methods did away with a fallow period; coots were shot in large numbers for food until the early 20th century; badgers were also eaten, the fat used as a substitute for lard or to ameliorate kidney stones or joint pain, and the pelts used for human clothing and dog collars; Castle Loch in Dumfries and Galloway was as attractive to anglers of old as it is to those of today, containing "Pikes, Green backs, Breams, Vetches, Pearches with some others".

There is a short chapter at the end which looks at species which have increased or decreased to date. This needs careful consideration as the author deals with distribution, not abundance. That said, about 20% of species have declined but this is balanced by a similar 20% that have expanded and Raye tries to explain both trends. The voluminous references occupy nearly 30 pages in small print and are a tour de force. The author has worked for the Royal Society for Protection of Birds and now teaches at the Open University. A fellow of the Linnean Society, he is interested in the distribution of plants during the same historical period and I wonder if a botanical companion volume is in preparation.

Overall, this is an undoubted labour of love that, despite all the difficulties of interpreting historical records, makes for a wonderful read. It is not a book for tackling end-to-end, but one to dip into. Its most important message is not the doom and gloom of habitat loss or species decline, but the absolute need for recording effort as a basis for understanding change.

Tony Payne

Trees and Woodlands

George Peterken
Bloomsbury Publishing, 2023. 416 pages, hardback with 300 illustrations. ISBN 9781472987013.
£40.00

Trees and Woodlands is number 12 in the British Wildlife series on aspects of British natural history. George Peterken has already contributed to this series with a book on *Meadows*, a superb volume which I reviewed for *The Glasgow Naturalist* and, indeed, hurriedly purchased. However, *Trees and Woodlands* represents the main theme of George's lifelong work. His dedication from his graduate years, through 60 years in woodland and forest ecology, has influenced the categorisation of woodland, management and

conservation. His formative ideas he would share with others to whom he gives credit throughout, particularly to Oliver Rackham. Peterken's knowledge and passion are augmented in this volume by nearly 300 excellent photographs covering all aspects of a very complex subject. The scope of woodland description was necessarily limited by the prior publication of *Woodland Flowers* by Keith Kirby (2020) in this series. Otherwise, all aspects of British native and semi-native woodland, and some comments on forestry, are covered in this volume. In addition, the influence of trees and woodland on art, culture and well-being are examined and discussed in well researched detail.

In the Preface and Introduction, Peterken outlines his own background of family holidays at Ringwood on the edge of the New Forest, followed by Ph.D. studies on holly substantially in the New Forest. Ultimately his employment was largely in forest ecology and conservation, including a sabbatical spent at Harvard and extensive visits to European woodlands. He has widespread experience of woodlands in the British Isles - 146 woodlands named and located on a site location map – leading to the development of a personal concept of the term "ancient" and a deep understanding of the influence of man to our present perceptions. The following discussion of "Natural woodlands" enlarges on this theme, tracing woodlands from Neolithic times to the present, including comments on the conifer plantations following the Second World War. These last are easy to define, but generally Peterken recognised just how inadequate the existing definitions of woodlands were, and gives due credit to early pioneers of categorization.

Prior to developing this concern, Peterken provides several chapters of sound background information. First, a chapter on "The forms of trees and shrubs" - how so many interacting factors give different shapes to different tree species in each woodland. Then follows a chapter on "Forest dominants" - the large trees that substantially define our descriptive name of the woodland and then a chapter on "Pioneers, small trees, shrubs and climbers". Throughout, the illustrative photographs are excellent, giving attractive backing to the very informative text. This detail allows the reader to better grasp the following chapters on named, natural woodlands and how generations of people have used and interacted with the woodlands, this section finishing with the development of conservation management and woodland nature reserves.

Peterken's Nature Conservancy work in particular led him to recognise how difficult it was to properly describe the woods he visited. This made management advice and conservation development more challenging. He recognised that ecology, geology, geography, vegetation and habitat all needed to be encompassed and Peterken's resulting classification is a ground-breaking achievement. The chapter on "Woodland types and their distribution" gives full details of a system which is universally applicable at all levels and has been the categorisation used for many years. Particular credit is given to the contribution of the late Oliver Rackham to this massive achievement. This type of classification allows the whole concept of habitat to be illustrated with all forms of animal life, plants and fungi and their interactions and significance, giving a sound basis for the conservation and management which is so important to Peterken.

In subsequent chapters we are treated to the history and description of the beneficial feelings trees and woodlands give us, followed by the cultural appreciation of trees including their significance in the world of art and conservation concepts. Impressively researched and presented with illustrations. Finally, in a chapter "Looking forward", we are forced first to look backwards. I am of the same generation as George Peterken. I too remember the good, the bad and the ugly of the last 60 years. He describes the changes he has helped to bring about, e.g. the aims of Forestry - the Broadleaved Policy of 1985. Introductions are outlined - grey squirrels, imported beetles, etc. Also, there is a sadness expressed that we have not learned from past mistakes, particularly with fungal and bacterial pathogens. However, Peterken describes many successes especially with community involvement (his own long involvement with Lady Park Wood), and the conservation concepts he has helped people grasp.

Who does this book target? There are many books on trees and woods. My bookshelves are full of them, my personal background being in botany, mycology and landscaping. However, this book holds a lot of interesting information and is very well written by someone uniquely qualified to deal with a broad-based subject but with real depth and perception. Its concepts and contents are modern; George Peterken was ahead of his time and still is. For a younger generation, whether a general reader with an interest in natural history, a student or a professional biologist of any sort (and let us hopefully include politicians and administrators), this volume has much to give and is beautifully presented.

Alison Moss

Goethe in the Age of Artificial Intelligence. Enlightened Solutions for a Modern Hubris

Malte C. Ebach
Palgrave Macmillan, 2023. 130 pages, hardback with 20 figures. ISBN 9789811967405.
Hardback £34.99; eBook £27.99

This is a short book of 7 chapters and an epilogue. Each chapter has references and there is a final reading list. Chapter titles to whet the mental appetite include "Goethe in the Age of AI", "AI and the Modern Hubris", "How to Remedy Direct Observation", and "Getting Rid of Bad Metaphysics". It could almost be read in an afternoon if one could muster the necessary concentration and stamina. The style is both direct and reflective, the content very wide, giving any reader much to ponder on. Some lines on page 10 state the book's subject and our shared situation – "*This book is about us, human observers of the natural world, in a global economy that is becoming automated, in a*

scientific community that is slowly replacing human observation with machine learning and models."
The author stresses that the responses to our situation lie in the transformation of each individual scientist and he uses Goethe's life as subject for such possible transformation. Goethe is Johann Wolfgang von Goethe (1749-1832), poet, novelist, playwright, geologist, colour theorist and experimentalist, botanist, morphologist... The chapters present aspects of Goethe's life, growth and development interpenetrated with Ebach's reflections on artificial intelligence, machine learning, big data, observation and discovery, good and bad metaphysics and the history of science.

Ebach, an Australian with Germanic heredity has a fine collection of notable publications, both as sole and co-author, across wide horizons of natural history. Herein he tries to re-form and re-fuse the sundered world of our experiences of, and with, Nature (note the capital) using Goethe's life as a guide. How successful this is, depends I think, on where each one of us is on our own life's journey, rather like Ebach's hero Goethe. And how receptive we are at each moment to re-thinking our understanding of the nature of things and the things of Nature. We also have to try to grasp the sense and meaning of some almost untranslatable and elusive German terms. Goethe the dilettante grew on, transforming and metamorphosing to become scientist, poet, artist and novelist. In sum, a very rare creature indeed - in forgotten Thomas Carlyle's forgotten words – "the Universal Man". And a creature now largely shunned by the current English-speaking world, especially the scientific world. Why should this be? Possible answers to that question lie far beyond the scope of this review.

Ebach's counterpoint then to Goethe's life is our present predicament and our infatuation with, and seduction by, technology – "the Modern Hubris". Can Goethe's life's journey really come to our aid here? Goethe fretted and fidgeted about spectacles, microscopes and telescopes filtering and corrupting his sensual, perceptual and conceptual acuity. Thankfully for Goethe's mental well-being he did not have to experience televisions and Truman shows, smart phones and the internet, and the call centre. Ebach remains remarkably sanguine and balanced with respect to technology, provided we are willing and able to recognise the relationship for what it really is. I, for my part, am less sanguine. But perhaps it takes manners, morals and metaphors to maketh man.

Unaddressed by Ebach is the larger question of whether Nemesis always follows Hubris. Is life, the universe and everything deterministic? A moment's reflection on David Hume's sound Scottish scepticism (shaped by Scottish historical legal form?) on all matters suggests that a "not proven (yet)" judgement might be the correct one here, and a victory for Pandora's hope over the demons of experience? Meanwhile we all choose to be click-bait addicts, being the information-seeking creatures that we, and all other organisms, are. Ebach does not surrender to the easy delusions of prediction, and his book stays grounded in the changing form, growth and metamorphosis of Goethe and his thoughts and how these can relate to our situation. Ebach take us to the very edge of our current Hubris, and probable Nemesis remains unexplored.

Can I recommend this book? Most certainly. Is it an easy read? No. But if our aim is to have civilisation, culture and science where people matter, and a world where machines serve people, and not the reverse, it is necessary reading.

Robin Bruce

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PhotoSCENE 2023-24

PhotoSCENE Natural History Photographic Competition.
The annual PhotoSCENE competition is sponsored by Glasgow Natural History Society and the University of Glasgow School of Biodiversity, One Health and Veterinary Medicine. It aims to promote an interest in Natural History and the work of SCENE (Scottish Centre for Ecology and the Natural Environment, the University's field station at Rowardennan, Loch Lomond), promote linkage between the School and the Society, and provide pictures for publicity purposes. All entrants are thanked for making the effort to enter the competition and prizes totalling £500 were awarded at the Society's photographic night in February which always provides members with an enjoyable and interesting evening. This year there were 75 entries from 18 people.

Andy Wilson

Overall winner:

David Stone - Common buzzard (*Buteo buteo*), Forres, Scottish Highlands, 9th June 2023.

Other prize winners:
These include the photograph by Scott Shanks, which was a Second equal Prize winner and features on the back cover, and that by David Stone, which was highly commended and features on the front cover. Information on these photographs is provided on the inside front cover. The other prize winners and highly commended entries are shown below.

Second equal Prize winner:

Robyn Haggard - Mating emperor moths (*Saturnia pavonia*), near Ben Shee, Glen Sherup Horseshoe Loop, Ochil Hills, Scotland, 7th May 2023.

Third equal Prize winners:

Richard Sutcliffe - Comma butterfly (*Polygonia c-album*), Garscube Allotments, Glasgow, Scotland, 5th August 2023.

Rebecca MacArthur - Emerald damselfly (*Lestes sponsa*), Scottish Centre for Ecology and the Natural Environment, Rowardennan, Loch Lomond, Scotland, 14th September 2023.

Ewan Parry - Jackdaws (*Coloeus monedula*), Garscube, Glasgow, Scotland, 14th December 2022.

Highly commended entries:

Adhip Aditya - Herring gull "heart" (*Larus argentatus*), Millport, Isle of Cumbrae, Scotland, October 2022.

Sarah Longrigg - Dancing dandelion seeds (*Taraxacum* sp.), Milngavie, East Dunbartonshire, Scotland, 10th June 2023.

Richard Sutcliffe - Speckled wood butterfly (*Pararge aegeria*), Fife Coastal Path near Kirkcaldy, Scotland, 10th June 2023.

Ewan Parry - Nettle-weevil (*Phyllobius pomaceus*), Lochwinnoch RSPB Reserve, Renfrewshire, Scotland, 19th June 2022.

David Stone - Fulmar (*Fulmarus glacialis*), Covesea, Scottish Highlands, 26th March 2023.

Scott Shanks - Male field cuckoo bumblebee (*Bombus campestris*), North Ayrshire, Scotland, July 2023.

Ewan Parry - Hoverfly (*Platycheirus albimanus*), Leuchars, Fife, Scotland, 22nd July 2023.

Pauline Wood - Whooper swans (*Cygnus cygnus*), RSPB Lochwinnoch, Renfrewshire, Scotland, February 2022.

Scott Shanks - Yellow-legged water-snipefly (*Atherix ibis*), Yorkhill Park, Glasgow, Scotland, 23rd May 2022.